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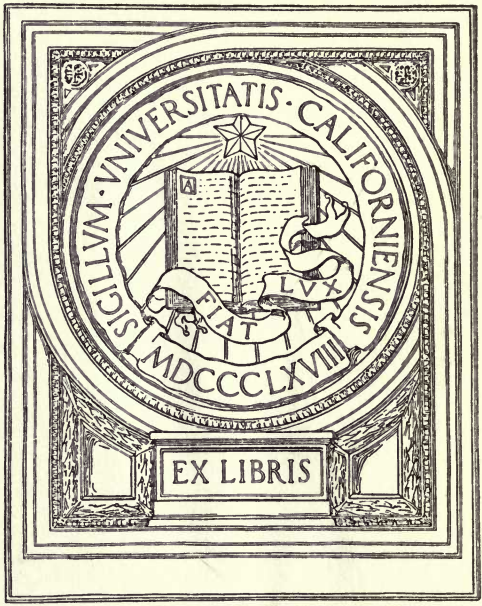
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SURVEYING MANUAL

DESIGNED FOR THE USE OF

FIRST-YEAR STUDENTS IN SURVEYING AND ESPECIALLY FOR THE USE OF NON-CIVIL ENGINEERING STUDENTS

BY

HOWARD CHAPIN IVES

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FIRST EDITION

FIRST THOUSAND

NEW YORK

JOHN WILEY & SONS, INC.

LONDON: CHAPMAN & HALL, LIMITED

1914

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Stanhope Press
F. H. GILSON COMPANY
BOSTON, U.S.A.

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"
Surveying Manual.

PREFACE

As stated in the sub-title, this manual is intended to be used by first-year students in surveying and especially for non-civil engineering students. It is particularly adapted to the needs of mechanical, electrical and chemical engineers, and of students in agriculture and architecture, as well as those in secondary schools. On the other hand, it is extended enough to be of service to first-year students in civil engineering as a field guide.

Attention is called to the following features:

1. A description of each instrument or class of work followed by problems worked out in detail. It is believed that by this arrangement oral instruction may be greatly reduced.

2. Sample field notes reproduced at the same scale as drawn, which is practically that in a regular field book. By this method, a reasonable standard of execution is presented. Since several methods and suggestions are given in each problem, the initiative of the student is not limited.

3. A set of tables sufficient for the ordinary work of surveying. These tables are included for ease of access.

The author is indebted to C. L. Berger and Sons for Figures 3, 4, 5, 6, 18 and 34; to the Bausch and Lomb Optical Company for Figure 17; to W. and L. E. Gurley for Figures 16, 29 and 55; to John Wiley & Sons for furnishing Tables I to VIII and XI to XIII; and to the Superintendent of the United States Coast & Geodetic Survey for furnishing the material for Tables IX and X. Tables I to VIII are from Ives and Hilts' "Problems in Surveying, etc.," and Tables XI to XIII are from Webb's "Railroad Construction."

The author wishes to make especial acknowledgment to Mr. Albert S. Crandon who made most of the drawings for the illustrations and sample notes.

H. C. I.

WORCESTER, MASS.,
August, 1914.

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SURVEYING MANUAL

CHAPTER I

GENERAL INSTRUCTIONS

Introduction. In this chapter there will be given several suggestions and directions which apply to all surveying work regardless of the particular instruments used.

Accuracy. The most important thing in a survey is that the work be sufficiently accurate for the purpose in hand. The accuracy should be not only reasonable, but consistent. For instance, in making a survey of a tract of land where grass plots, walks, etc., are to be located as well as the boundary lines, the former should not be located as accurately as the latter, and time will be wasted if measurements are carried to the same precision for both.

Computations. A rule very commonly observed in computation is that the work be carried one decimal place further than that to which the measurements were made in the field.

Objects of a Survey. A student survey is made for the following objects: to give practice in the use of instruments; to secure data for computing; to obtain information for making a plot or map. These last two objects are often the basis of the design of some proposed work. In practical work, the first object of course drops out of consideration. Naturally in this book several of the problems are given with a view that students shall become familiar with as many of the different instruments as possible, and no computations or maps are made in such cases.

Surveying. The work of the surveyor may be divided into three parts: (1) The Care and Adjustment of Instruments; (2)

Field Work; (3) Office Work. No line of distinction is made between these parts in the problems of this book.

In *plane* surveying no account is taken of the earth's curvature, while in *geodetic* surveying account is so taken. The three principal things in the work of plane surveying are: the measurement of the distances; the measurement of the differences of elevation; and the measurement of angles. In geodetic work the following are added: the determination of latitude, longitude, time, and true north. In some parts of plane surveying, such as hydrographic work, account of time is frequently taken but there is no actual determination of such. Also, in determining the declination of the needle and in surveys requiring the use of a true meridian a knowledge of certain astronomical terms used in geodetic work is necessary.

Location of Points. In plane surveying the *relative* position of points is determined, while in geodetic surveying their *absolute* positions on the earth's surface are found. With three angles of a triangle given, there may be an infinite number of such triangles on the earth's surface, while if the latitude and longitude of one station of the triangle are determined, the triangle has an *absolute position* on the earth's surface.

The relative position of a point is found in one of the following ways:

I. By an angle from a given line and a distance from a given point, as 1 of Fig. 1. This method is used with the transit both in ordinary surveys, and in the location of railroad curves.

II. By measuring the distances from two given points to the required points. 2 of Fig. 1. This method is used in chain or tape surveys and in referencing points.

III. By rectangular coordinates, i.e., by the perpendicular distance from a line to the desired point and the distance along the line from a fixed point. 3 of Fig. 1. This method is often used in the location of corners of buildings.

IV. By the intersection of two lines, located by an angle measured at each end of a given base line. 4 of Fig. 1. This method is used in plane table work and the location of soundings in hydrographic surveys.

V. By a distance from one given point and an angle from another as in 5 of Fig. 1.

VI. By the intersection of two diagonal lines joining two pairs of points so that they intersect at a given point. 6 of Fig. 1. This method is used in referencing points, and in setting monuments to replace the stakes in any survey.

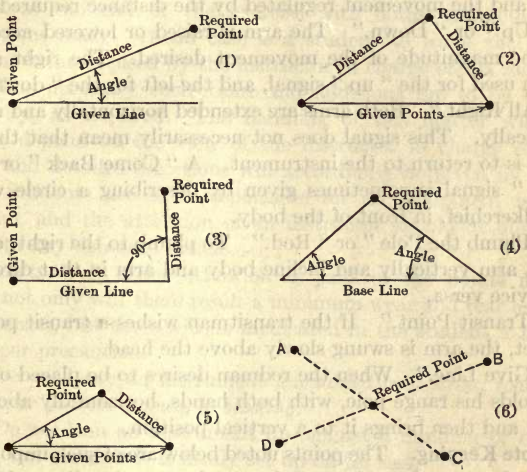


FIG. 1

Sights. On all classes of surveys sights are given in one of three ways: first, by use of a range pole; second, by use of a plumb-bob; and third, by a pencil. On long sights the cross-wires cover such a width that a range pole must be used in giving a sight. It is particularly important in such cases, that the range pole be plumb and it may be made so by first balancing it between the thumb and first finger of each hand and then moving it laterally to the point. For medium length sights the plumb-bob string may be used, and where the stake or point can be seen, a pencil may be used in giving the sight. In all three cases, when

sighting with the instrument the lowest point of the range pole, string or pencil should be taken.

Field Signals. A proper system of signals should be arranged. It is advised that hand signals be used, in preference to vocal signals except at close intervals. Following are some of the more common signals:

" Right " or " Left." The arm is extended in the desired direction and the movement regulated by the distance required.

" Up " or " Down." The arm is raised or lowered according to the magnitude of the movement desired. The right arm is often used for the " up " signal, and the left for the " down."

"All Right." Both arms are extended horizontally and moved vertically. This signal does not necessarily mean that the rodman is to return to the instrument. A " Come Back " or " Return " signal is sometimes given by describing a circle with a handkerchief, in front of the body.

" Plumb the Pole " or " Rod." To plumb to the right, extend right arm vertically and incline body and arm in that direction, and vice versa.

" Transit Point." If the transitman wishes a transit point to be set, the arm is swung slowly above the head.

" Give Line." When the rodman desires to be placed on line, he holds his range pole, with both hands, horizontally above his head and then brings it to a vertical position.

Note Keeping. The points noted below are of such importance that they are brought together under one heading, although attention will be called to them in the different problems.

1. The date, personnel of party, and numbers of instruments should be given for each problem.

2. At the top of each double page the number of the problem and its title should be given.

3. Number each right-hand page. Place an index in the back of the book. The index should contain the number and title of the problem and the page on which it is given. Keep this index up to date.

4. All notes, descriptions, etc., must be in the Reinhardt style of lettering and well executed. No writing will be allowed in the book.

5. Notes must be entered in the field book during the progress of the work, and in no case are they to be taken on small slips of paper and transferred to the book later.

6. Only hard pencils are to be used.

7. The student's name is to be placed in waterproof ink on the outside of the book.

8. *Unless notice is given to the contrary*, books are to be submitted at the end of the exercise with notes complete and corrections made. In no case is a student to leave the work without being excused by the instructor in charge of his section.

9. The necessary corrections and additions are to be made promptly, as required. The handling of this matter will, of course, depend on the view of the instructor in charge of the work, and detailed directions will accordingly be given by him.

10. Students are held responsible for all equipment issued to them, and the attention of an instructor should at once be called to any damaged article.

"Don'ts." If strict attention is paid to the points noted below not only will there result a minimum wear and tear on the instruments, but there will be inculcated in the student a habit of proper precaution.

1. *Do not* leave an instrument *unguarded in a street, road, or pasture, or in close vicinity to blasting.*

2. *Do not* lean an instrument up against a building or other object, but see that it is firmly set up on its legs.

3. *Do not* carry an instrument over your shoulder until you are out of doors, but carry it under your arm.

4. *Do not* strain any of the screws of an instrument, but remember that they are made of brass, and need to be clamped but lightly.

5. *Do not* attempt to force the tangent-screws to their extreme limit in either direction.

6. *Do not* pass in equipment which is liable to rust, until it has been thoroughly wiped off.

7. *Do not* fail to see, when you pass in an instrument, that it is centered and leveled; that the needle is raised; that sunshade and cover are with it; that object glass is drawn back by focusing screw; that plumb-bob cord is wound around the bob.

8. *Do not* forget to keep the needle raised when it is not in use.

9. *Do not* tie up tapes with plumb-bob cord, but see that they are securely tied up in the form of a figure 8 when they are without reels.

10. *Do not* try to throw out a tape as you would an engineer's chain. It won't work.

11. *Do not* stand directly back of your instrument when sighting through it, but place yourself in a *comfortable* position on the side, and bend your body sidewise.

12. *Do not* batter up the points of plumb-bobs.

13. *Do not* chop stones with the hatchet or brush-hook.

14. *Do not* throw equipment around in a careless manner, but remember that each article is an instrument of precision.

15. *Do not* fail to return stakes to the college when not used for permanent marks.

16. *Do not* forget to carry your magnifying-glass and adjusting pin with you.

CHAPTER II

THE CHAIN AND TAPE

Instruments. The instruments commonly used for measuring lines are the engineer's chain (Fig. 2a), the Gunter's chain (Fig. 2b) and the tape. The engineer's chain is either 50 or 100 feet long and is divided into links of one foot each. The Gunter's chain is 66 feet in length and is divided into one hundred links of 7.92 inches each. Every ten-link point is marked by a specially notched brass tag. On the hundred-foot chain and also on the Gunter's chain both the tenth and the ninetieth links each have a tag with one notch on it; at the twentieth and eightieth links each tag has two notches, and so on, the fiftieth link usually having an oblong or a circular tag. Care must therefore be taken that the reading be made from the proper end of the chain.

The Gunter's chain was used in laying out the United States Public Lands and in some of the earlier surveys in various sections of the country. It has two advantages: first, there are 80 chains to the mile; and second, having found the area in square chains, the value in acres may be found by dividing by ten or pointing off one to the left.

The principal objection to the use of the chain is that its length is not permanent, due to the number of wearing surfaces and to the liability of the links becoming bent.

There are four common kinds of tapes: First, tapes where only the end graduations are marked by fine lines, the tape extending a short distance beyond these lines on both ends. This form is used in geodetic work. Second, where the tape is graduated to feet, tenths and hundredths throughout, the zero point being usually at the end of the tape, with a short piece beyond the hundred-foot end for attaching in a box. (Fig. 2d.) This form is generally used for city work. Third, where the tape is graduated to feet and the end feet to tenths. This form is used

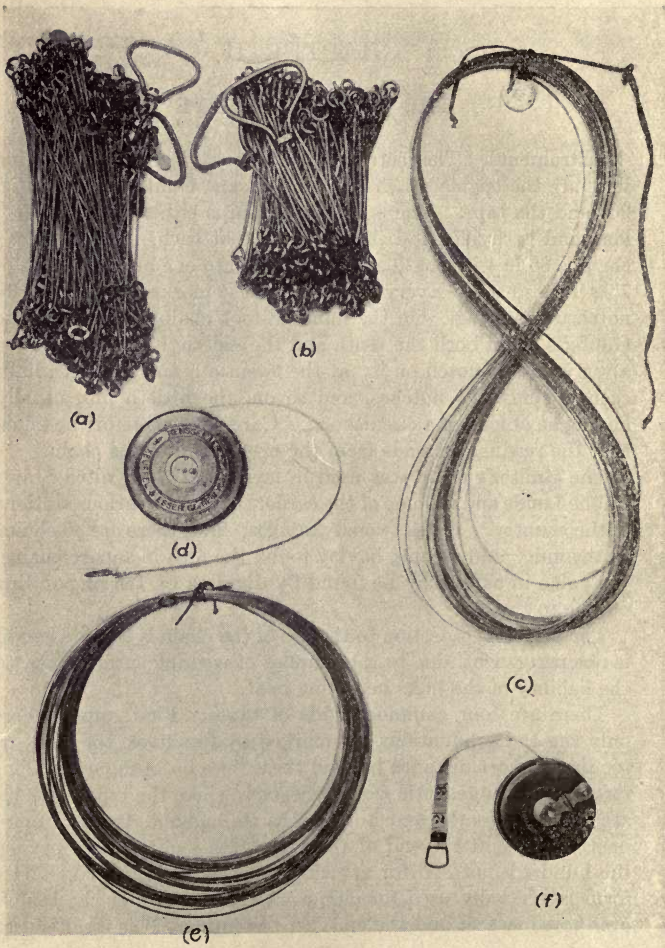


FIG. 2.

for ordinary work. There are two common forms of this tape, the Chicago (Fig. 2c) and the band (Fig. 2e) or Roe. Fourth, the metallic or woven tape (Fig. 2f). It is used for rough and approximate work, such as filling in details.

Remark. The graduations in the last three forms may of course be to feet and inches, instead of feet and tenths.

Accessories. The accessories used in chaining are a set of marking pins and plumb-bobs, together with two or more ranging poles for lining purposes. The marking pins are used to mark the ends of the tape, and after the tape is made horizontal a plumb-bob is used for transferring the point at the end of the tape to the ground.

Use of the Chain or Tape. Since horizontal distances are always desired in surveying, the chain or tape must be held horizontally while measuring. The work of measuring a line on sloping ground is as follows: A range pole is placed back of one of the points (preferably the lower one). After undoing the chain or tape, the head chainman proceeds along the line until the zero end of the tape comes to the rear chainman. The head chainman is then placed on line either by the eye of the rear chainman, or in some cases, by the transitman. The tape is then made as nearly horizontal as possible and its end is transferred to the ground by use of a bob. A marking pin is set where the bob strikes the ground. In measuring it is better for the head chainman to stand at one side of the tape, grip the handle of the tape in one hand, and use the bob with the other hand. The pin should be pressed into the ground on a slant, so that in plumbing the bob may strike the pin where it enters the ground.

Where the chain is used, the outside of the rear handle is brought against the pin and the head chainman plumbs from the inside of his handle. This is necessary because the standard length of the chain is from center to center of handles. In measuring with a tape, the graduations are used.

If the ground falls rapidly, a partial tape length must be used. This operation is called " breaking chain."

Care must be exercised in keeping account of the number of tape lengths. There are usually eleven pins in a set, the head chainman either placing a pin at the starting point, or giving one

to the rear chainman. After the forward pin is set, and the signal is given, the rear chainman removes his pin from the ground. The head chainman, having used all of the set, awaits the arrival of the rear chainman. The pins are then checked up, the one remaining in the ground not being counted. The work proceeds in this way until the whole line is measured. In case of "breaking chain" a predetermined system of record must be adopted.

Precautions. There are three difficulties to be overcome in measuring. First, the tape must be made horizontal; second, a constant tension must be exerted; and third, the point at the forward end of the tape must be properly transferred to the ground. It is very difficult to do any of these exactly.

We may judge in one of three ways whether or not the tape is horizontal. A level vial may be placed near each end of the tape; or we may try to secure a right angle between the tape and the bob; or finally, the rise or fall in a certain distance may be estimated (or actually measured by use of a level and rod), and the tape raised to offset this difference in elevation. The last method is the one most commonly used.

A constant tension may be secured by use of a spring balance. The *normal tension* is a tension such that the amount of elongation of the tape will counterbalance the sag. The normal tension for a tape is not particularly excessive, but it is decidedly so for a chain. For this reason, in using a chain, a certain tension lower than the normal is used in the field, and whenever advisable a correction is made.

If the measurement is made down hill, it is less difficult to transfer the forward point to the ground than otherwise, inasmuch as one end of the tape is at a fixed point. Provided the head chainman stands and holds the tape as previously directed, he will soon become proficient in his work.

Errors and Mistakes. Among the common sources of error in measurement of distances are: poor alignment; incorrect plumbing; variable or insufficient pull; variable temperature; and incorrect length of tape.

The following mistakes are liable to occur: omitting a whole chain or tape length; reading from the wrong end of the tape or chain; transposing figures in reading, such as 48.26 for 48.62;

and reading the wrong foot, as 68.26 for 69.26. Errors and mistakes may be avoided to a great extent by proper attention and care.

Testing the Chain or Tape. A chain or tape is usually standardized at 62° F. under a ten-pound tension and supported throughout. If conditions other than these prevail in the field, the proper corrections should be made.

For each change of one degree in temperature, a chain or tape will change by 0.0000065 of its length. A standard base line may be laid off, its length found, and tapes or chains compared with it. Assuming a tape whose length l is known under standard conditions, the base line may be laid out as follows: In a free passageway, practically level, place a permanent mark to indicate the beginning of the base line. Stretch the tape at the proper tension, note the temperature, and mark the end of the base line. The length of the base is then equal to $0.0000065\ (T - 62°)\ l$, where T is the temperature of the tape. Any chain or tape may be compared with this line, the temperature at the time being noted in order to reduce the length to that at 62° F. The comparison of lengths for this rough method may be made by use of a magnifying glass and a finely graduated scale. For the detailed work of testing see Problem A4.

For rough work, if the chain or tape is practically correct in length under standard conditions, the temperature correction may be neglected.

Since in the field the chain or tape is usually suspended while in use, the pull must be increased to overcome the effect of sag. The tension necessary to accomplish this is called the *normal tension* and has previously been discussed. The method of finding the normal tension is given in Problem A4.

Other Measuring Instruments. The *pedometer* is a pocket instrument for registering the distance covered in pacing. It resembles a watch in form, and when in use is attached to the belt in an upright position. The jar received at each step causes a weighted lever to drop upon an adjustable screw. The lever returns to position by aid of a spring, thereby turning a ratchet wheel, transmitting the motion to record on the dial. The adjustable screw may be regulated to any length of pace. The

passometer is an instrument built on similar principles to the pedometer, but registers the number of paces only. The *odometer* is an instrument which is attached to the wheel of a vehicle to record the number of revolutions.

The engineers' transit, sometimes called the universal surveying instrument, may be equipped with two horizontal wires. These wires are so spaced that they intercept one foot on a self-reading rod for every interval of 100 feet. These wires are called stadia wires, and measurements so taken are called stadia measurements. Single measurements taken by the stadia alone may not compare favorably with those taken by the tape, but owing to the compensating nature of the errors, the results in a stadia survey will compare favorably with those in rough surveys made in other ways.

Use of Tape Alone. The chain or tape alone may be used in finding the area of closed figures, or in finding the areas of figures with curved sides. Either may be used in many rough problems. In railroad surveying, curves for branch lines and turnouts are sometimes laid out with the chain or tape. In any case the nature of the problem will govern the instrument to be used.

SPECIAL EXERCISES

The exercises below may be worked out by the student by use of the chain or tape alone. It was thought best not to work them up in the form of special problems, as in Problems A1 to A5.

1. To measure the distance between two points which are not visible from each other.

Solution. Place range poles at the two points. The chainmen range themselves in between the points by successive approximations. After the line is thus established it may be measured.

2. To measure the distance between two points when woods intervene, without clearing the true line.

Solution. Run out a trial line by use of range poles leaving fixed points. Find the resulting error at the end of the line and move all points over their true proportional amount. Then measure the length of the true line.

3. To lay out a right angle at a given point in a given line.

Solution. A triangle whose sides are multiples of 3, 4, 5, will be right-angled. When the tape is used, 5- or 10-ft. loops may be left at two of the three angles. For instance, standing at the given point, hold the 12- and 22-ft. points of the tape. Place the tape along the given line and hold at the 38-ft. graduation of the tape. Coil the tape, bringing together the 38- and 48-ft. points, thus forming a 10-ft. loop. Hold the 73-ft. and zero graduations together. Then the angle formed at the given point is a right angle.

4. To prolong a line beyond a given obstacle.

Solution. First, by an isosceles triangle. Second, form an equilateral triangle. Third, by rectangular offsets.

Note. In all cases the longer the sights the more accurate will be the work.

CHAINING PROBLEMS

PROBLEM A1. MEASUREMENT OF THE LENGTH OF A LINE WITH A STEEL TAPE OR CHAIN

Equipment. Hundred-foot steel tape or chain, two or more range poles, set of marking pins, two plumb-bobs, hatchet, stakes and tacks.

Problem. *To measure the distance between two fixed points.*

Method. If no permanent monuments are available, set two stakes about 1000 feet apart. The difference in elevation of the stakes should be considerable and the slope between them variable. Set a range pole in back of one stake, and measure towards it from the other stake. For the detailed work of measuring, see pages 9 and 10.

In undoing the chain, take the two handles in the left hand and the chain bundle in the right hand. Throw the bundle in a direction opposite to that in which the measurement is to be made, the handles still remaining in the left hand. When a tape is to be used, it is either unreeled or, in case it is done up in the form of a figure 8 or a circle, taken off strand by strand, being careful that the pressure is not released.

Measure the distance at least three times by plumbing, re-

membering that when the slope is steep the chain must be broken at frequent intervals. Measure twice along the slope. The measurements along the slope are made in order to show the effect of slope on distance, and, provided the inclination is not too steep, the inclined distance may be used in Problem A2 in finding the length of pace.

Computations. Compute on the right-hand page the average length of line as obtained by plumbing, and the same for the measurements along the slope. In each case find the ratio of the extreme range to the mean length. This should not be greater than 1/1000 part of the mean length.

The extreme range is the difference between the largest and the smallest measurements.

Form of Notes. Follow the form given below, being particularly careful to meet all requirements as indicated under *Note Keeping* on pages 4 and 5.

PROB. A 1. MEASUREMENT

Line	Dist.	Direct.	Distance along Slope.
A-B	968.4	Out	
B-A	968.3	Back	
A-B	968.3	Out	
B-A			970.2
A-B			970.3

OF A LINE

Oct. 9, 1911.

E.S. Cheever, Head Chainman.

D.L. French, Rear Chainman.

Equipment.– Range poles Nos. 7 and 19
Tape No. 14. Bobs Nos. 33 and 34.
Pins. Set No. 2.

Point A was, etc Point B was, etc.

Ratio of extreme range to mean length
$= \frac{.1}{968.33} = \frac{1}{9683.3}$.

PROBLEM A2. LENGTH OF PACE

Equipment. If the line measured in Problem A1 has not too great a slope, it may be used in determining the length of pace in which case no equipment is needed. Otherwise take a hundred-foot tape and a set of marking pins.

Problem. *To find the length of the natural pace and also an assumed three-foot pace.*

Method. Lay off a line from 400 to 700 feet in length on fairly level ground. Pace the distance at least four times, using a natural step, and then four times using an assumed 3 foot pace. In both methods always estimate the fractional pace at the end. Find, in a similar way to that given in the form below, the length of both the natural and assumed 3 foot paces, together with the number of each in a 100-foot length. Give the usual information on the right-hand page of the book.

PROB. A 2. LENGTH OF PACE.

Kind of Pace	No. of Paces	Mean Paces	Length of Line	Length of Pace	No. per 100 ft.
Natural	329.7				
	329.0				
	330.0	329.6	970.25	2.94	34.0
Assumed 3 ft. Pace	322.0				
	323.0				
	322.6	322.5	970.25	3.08	32.2

PROBLEM A3. MEASURING THE ANGLES OF A PENTAGON WITH CHAIN OR TAPE

Equipment. Chain or tape, three range poles, set of marking pins, two plumb-bobs, hatchet and stakes.

Problem. *To measure the angles of a pentagon with chain or tape.*

Theory. If equal distances (d) are laid off on the two sides of an angle, A, and the distance (a) between them measured, then $\sin \frac{1}{2} A = \frac{a}{2d}$.

Method. Drive five stakes, forming a pentagon with angles between 90° and 120° and sides from 200 to 400 feet in length. Starting at one station, place a range pole at each adjacent station. Lay off equal distances (d) on the two sides of the angle at this station, marking the points by pins. Measure the distance between the pins. The distance (d) should not be less than 25 feet. (The greater the distance, the more accurate the results.) Proceed in like manner at the other stations. Sometimes it may be better to measure the supplement of the angle instead of the angle itself. Measure the sides of the pentagon.

Computations. Calculate the angles by the formula given above. Assume one side of the figure as a meridian, and from the computed angles, find the bearings of the other sides. Compute the latitudes and departures and find the error of closure. See Chapter XI for complete explanation of these terms.

PROB A3. MEASURING THE ANGLES

Angle.	d	a.	$\frac{a}{2d}$	$\frac{1}{2}$ Angle	Angle
1	50'	76.90	.7690	50°16'	100°32'
2	50'	84.43	.8443	57°36'	115°12'
3	50'	81.02	.8102	54°07'	108°14'
4	50'	73.31	.7331	47°09'	94°18'
5	50'	87.49	.8749	61°02'	122°04'
Error	+ 0°20'		Sum of angles		540°20'

OF A PENTAGON WITH TAPE OR CHAIN.

Line	Bearing	Distance	Latitude	Departure
1-2	Assumed N	280.60	+280.60	———
2-3	N64°48'E			

Give a sketch of the field with the "error of closure"; also, party, date, equipment, etc., as usual.

PROBLEM A4. TESTING A CHAIN OR TAPE. (ROUGH METHOD.)

Equipment. Standard tape, chain or tape to be tested, two plumb-bobs, thermometer, scale, brass tacks, and a small piece of cardboard.

Problem. *First, to determine the absolute length of a chain or steel tape, and second, to determine the normal tension of the same.*

Theory. For each change of one degree in temperature a chain or steel tape will change by 0.0000065 of its length. By use of the standard tape, a base line may be laid down, its length found, and the chain or tape compared with it. For further information on this subject see page 11. The *normal tension* is the tension required to overcome the correction for sag.

Method. *First, to find the absolute length of the tape.* Place a brass tack in the floor of a passageway and make a finely scratched line on it. Stretch out the standard tape and when under a tension of ten pounds, with the zero graduation coinciding with the line on the tack, mark a point on a piece of cardboard placed at the 100 ft. graduation. The friction may be partially eliminated by going to the center of the tape and alternately raising and lowering it. The temperature at the 50-ft. graduation is noted.

If l = the absolute length of the tape at 62° F. and 10 lbs. tension, supported throughout, and

t = the observed temperature,

then l' = length of base line = $l + l\,(t - 62°)\,0.0000065$.

Apply the chain or tape to be tested to this base. Note the difference in length of the tape and base line under a 10 lb. tension with the friction eliminated. Make four trials of this test.

When a rough determination only is desired, provided the temperature is not far from 62°, the difference in length noted may be applied with the proper sign to the length of the base line. If a more precise value is wanted, it may be found as follows:

Let l'' = absolute length of tape to be tested;

t' = temperature at time of test;

d = difference in length of base line and tape;

then $l \pm d = l'' + l''\,(t' - 62°)\,0.0000065$, or from which

$l'' = l' \pm d - l'\,(t' - 62°)\,0.0000065$.

(Strictly speaking, l' in the last term of the right-hand member should be l'', but the resulting error is inappreciable.)

Second, to find the normal tension. Hold the chain or tape clear of the floor and note the tension necessary to bring the end graduations over the same points as when supported throughout under the 10-lb. tension. Plumb-bobs are used to bring the end graduations over the points on the floor. Make four repetitions of this part of the problem.

PROB. 44. TESTING A CHAIN OR TAPE.

Part.	Length of base. l'	Tested tape $l'-d$.	Temp.	Diff. d	Mean diff.	Tested tape at stand. cond. l''	Pull.
1	100.005	99.903					
		99.903	74°	-0.102		99.895	
		99.902	74°	-0.103		99.894	
		99.903	74°	-0.102	-0.102	99.895	10 lbs.
2							25 "
							24.5 "
							25.5 "
							25 "
					Average normal tension =		25 "

On right hand page give number of standard tape, together with its length; also, party, date, equipment, etc., as usual.

Notes extend across both pages.

PROBLEM A5. SURVEY OF A FIELD WITH A CURVED SIDE BY TAPE ALONE

Equipment. 100-ft. steel tape, 50-ft. metallic tape, set of marking pins, two plumb-bobs, range poles.

Theory and Method. A base line is laid out adjacent to the curved side of the field, and right angle offsets are taken from this base line to the points on the curved side. Offsets may be taken at regular or irregular intervals, the aim being to locate the principal changes in direction. The ends of the base line may be tied in to the other corners of the field, and the area of the remainder of the field may be found by dividing it into some form or forms of triangles.

Computations. Calculate the area of the portion between the base line and the curved line by the " Trapezoidal Rule," which in this case amounts to multiplying the mean of the offsets to two adjacent points by the distance between the offsets. Many other methods of computation are given in the larger textbooks on surveying.

Form of Notes. The notes may best be kept in the form of a sketch, together with a tabulation of offsets, if thought advisable. The particular form of notes may be left to the ingenuity of the student.

CHAPTER III

THE LEVEL

The Level. The *engineer's level* consists of a telescopic line of sight attached to a spirit level, properly supported, and revolving on a vertical axis.

There are two types of level, the wye and the dumpy. See Figs. 3 and 4. The telescope of the former rests upon Y-shaped supports, from which it may be removed, while that of the dumpy level is fixed. Their uses in the field are similar, but the methods of adjustment differ slightly.

FUNDAMENTAL PRINCIPLES

The Telescope. The *objective* or *object glass* is a compound lens which collects the light, and forms an image at the plane of the cross-wires. The cross-wires are attached to a brass ring called the *reticule*, which is held in place by capstan-screws. The eyepiece magnifies the image, which remains inverted with two lenses, and re-inverts with four lenses. The line joining the optical center of the wires is called the *line of collimation*. The construction of the instrument may best be seen from the sectional view in Fig. 5.

The Level Vial. The level vial consists of a glass tube bent or ground to the arc of a circle. It is nearly filled with ether or some other fluid, the remaining space being occupied with vapor, which forms a bubble. A line tangent to the inner surface of the vial at the center of the bubble is a level line, and is called the *axis of the bubble*. When the bubble is in the center of the tube its axis is horizontal, and if the bubble keeps a constant position in the tube, upon revolving horizontally, the line of collimation will describe a horizontal plane. The difference of elevation of points may then be found by taking rod readings upon them. The differences of rod readings, neglecting the curvature of the earth, will give the differences in elevation of points.

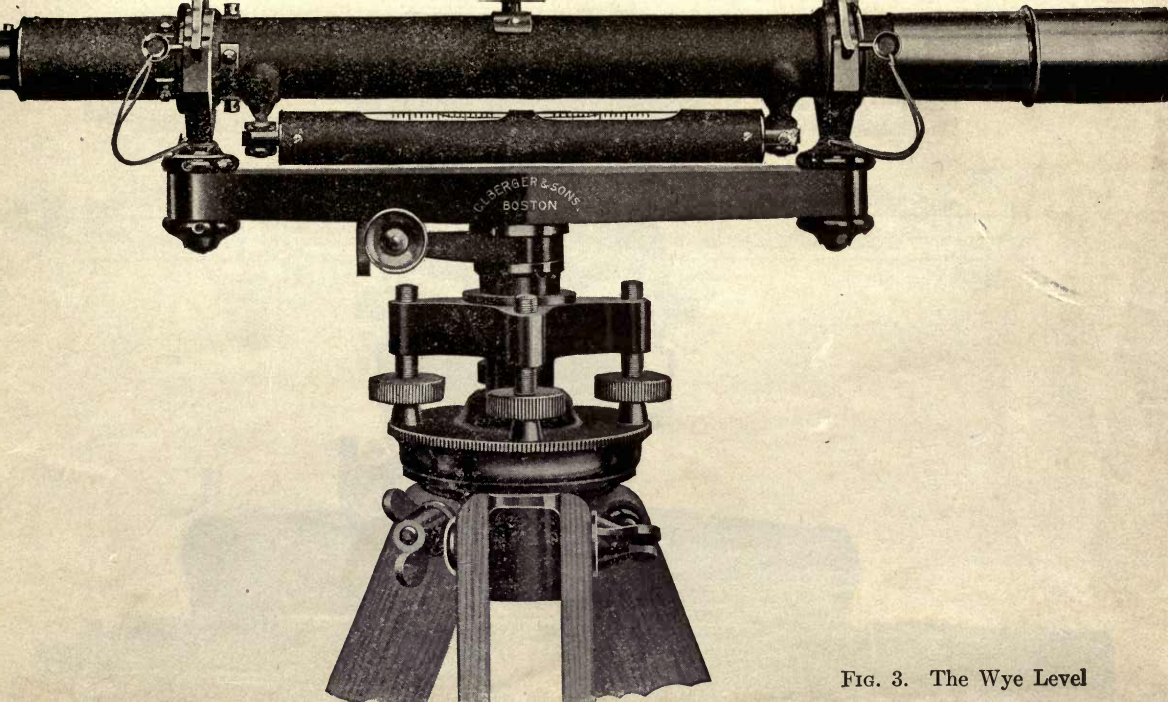


FIG. 3. The Wye Level

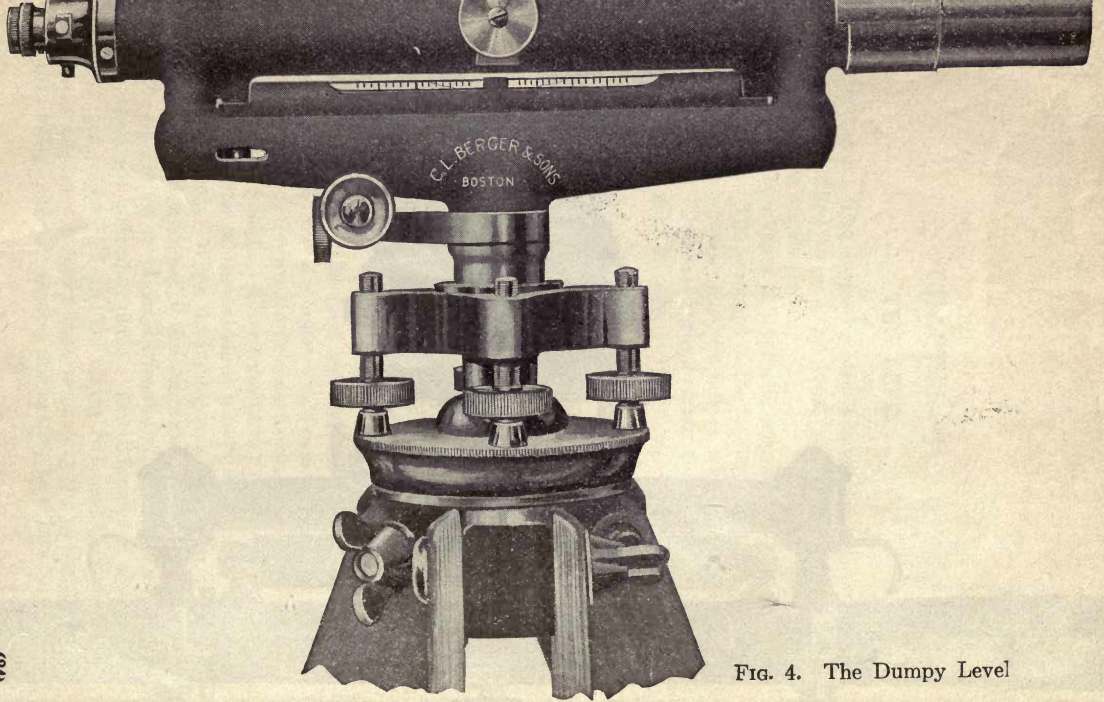


FIG. 4. The Dumpy Level

FIG. 5. Section of the Wye Level

The *principal* adjustments of the level consist in making the line of collimation parallel to the axis of the bubble, and in making the axis of the bubble perpendicular to the vertical axis of the instrument. The first adjustment is necessary where sights are not equal in length, but the second is a matter of convenience. For complete description of the adjustment of the level see pages 32 to 37, and for field notes on adjustments see Problem B4.

Focusing and Parallax. As previously stated, the object glass collects the rays of light from the object viewed and forms an image at the plane of the cross-wires. The image formed by the object glass should lie in the same plane as the cross-wires. If they do not coincide, there will be a slight movement of the cross-wires on the image as the eye is moved behind the eyepiece. This apparent movement is called parallax. It may be removed by changing either the position of the eyepiece, or by bringing the object into better focus. Ordinarily, before taking any sights, the object glass is thrown out of focus, and the cross-wires are brought into the most distinct position possible by changing the eyepiece. The telescope is then focused on an object; the eye is moved slowly in back of the eyepiece, and if there is an apparent quivering of the cross-wires on the object, it signifies that either the cross-wires are *not in the most distinct position possible, or that the object glass is not clearly focused, or both.*

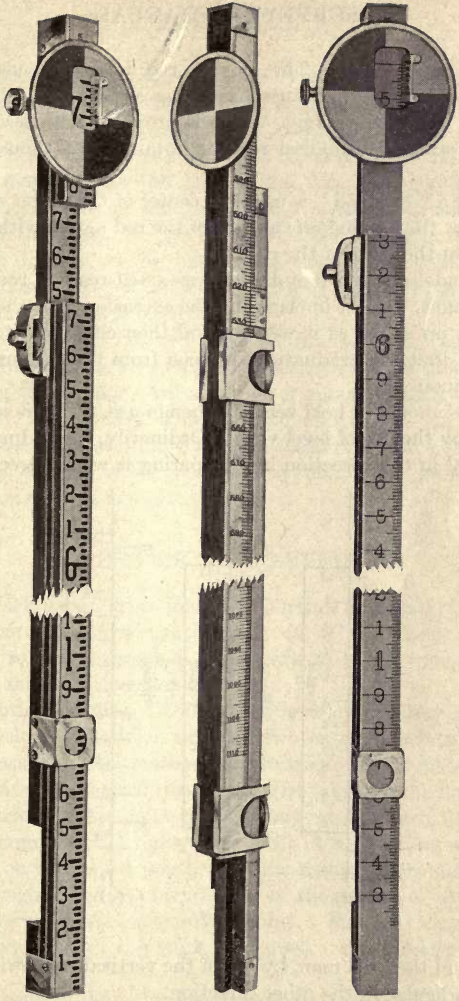
LEVELING RODS

There are two common types of leveling rod, the *Self-reading or Speaking Rod,* and the *Target Rod.*

A self-reading rod is one so graduated that the observer may take the reading direct. Where this form of rod is used, the observer, or note keeper — if there is one — records the reading, and the rodman merely holds the rod in a vertical position.

A target rod has a sliding target which is moved by the rodman as directed by the observer, until it coincides with the line of sight. The position of the target is then read by means of a vernier scale or a sliding scale. The notes in this case are kept by the rodman or note keeper.

The most commonly used self-reading rod is the Philadelphia rod (Fig. 6a). The New York (Fig. 6c) and Boston (Fig. 6b)



(a) (b) (c)

FIG. 6.

rods are target rods. The Boston rod is seldom used. The Philadelphia rod may be used as either a target or self-reading rod. By use of the target, which is provided with a vernier or a sliding scale, the smallest reading obtained is a thousandth of a foot.

In case a " long rod " is used the center of the target should be set so that the reading on the face of the rod agrees with the first reading on the back of the rod.

A Philadelphia rod may be used as a self-reading rod over its entire length, by first unclamping the extension near the bottom, sliding it up as far as it will go, and then clamping it. It will be noted that the graduations as seen from the instrument will be continuous.

The rod should be held vertical when in use. This is sometimes secured by the use of level vials. Ordinarily, the rodman makes it vertical in one direction by comparing it with a tree or other

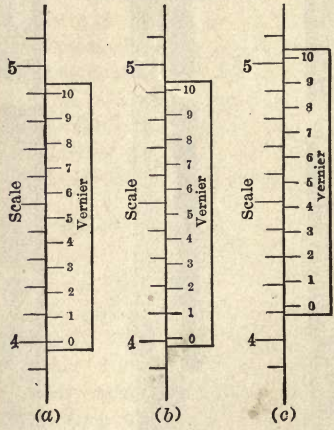


FIG. 7

object, and the level man, by use of the vertical cross-wire, makes it perpendicular in the other direction.

The Vernier. The vernier is a device for measuring smaller divisions of a scale or circle than can be done by estimation.

Fig. 7 illustrates a vernier, and (*a*) in this figure shows the principle of construction. The smaller divisions on the scale might represent those on a level rod, viz., hundredths. In order to construct a direct vernier reading to thousandths, nine parts of the scale may be taken off and divided into ten equal parts on the vernier. Then one division of the vernier equals nine-tenths of one on the scale, or $\frac{9}{10}$ of 0.01 = 0.009, and the difference between a division on the vernier and one on the scale is 0.001, or the distance between the 1 line on the vernier and the first line above 4 on the scale is 0.001.

In order to read the rod, first obtain the feet, tenths and hundredths up to the zero on the vernier, and for the thousandths look along the vernier until a line on it coincides with a line on the scale. The reading of (*b*) is 0.401 and that of (*c*) is 0.412 provided the distance from 4 to 5 is a tenth of a foot. It is to be noted that the *zero of the vernier* always marks the point on the scale whose reading is desired.

USE OF THE LEVEL

The level is used; (*a*) to find the difference in elevation between points a considerable distance apart; (*b*) to find the profile of a line; (*c*) to establish grade lines; (*d*) to make topographical surveys; and (*e*) to set slope stakes.

Differential Leveling. Differential leveling consists in finding the difference of elevation between two or more points at some distance apart. The method of procedure is as follows: Set up the level so that a rod reading may be taken on the first point. The elevation of this point being known or assumed, the height of the instrument (H.I.) may be found. A rod reading may then be taken on a forward point, and this reading (fore sight, F.S., or minus sight, − S.) subtracted from the height of the instrument will give the elevation of the point. The level may then be carried forward and the work continued until the last point is reached.

It is essential that the instrument be midway between the points upon which sights are taken, and the lengths of sight should preferably not exceed 350 ft.

A *bench mark* (B.M.) is a fixed point of more or less permanent character, the elevation of which is determined and recorded for future use. Bench marks should be set at frequent intervals and carefully described in the note book.

A *turning point* (T.P.) is an intervening point upon which the rod is held. The elevation of the turning point is found so that the level may be carried forward. The first rod reading that is taken after each set-up of the instrument is a *back sight* or *plus sight*. It is used in determining the height of the instrument. A rod reading taken to determine the elevation of a point is called a *fore sight* or a *minus sight*. It is to be noted that these terms do not necessarily refer to the direction of the sight; that is,

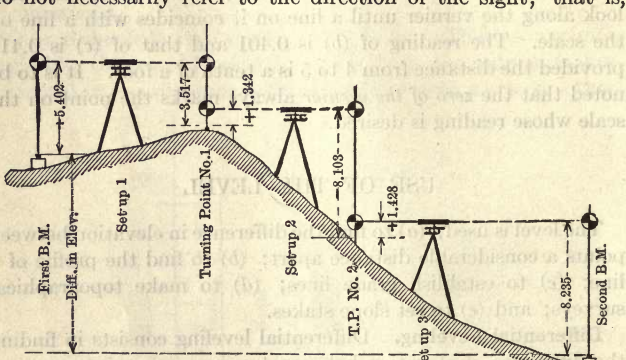


FIG. 8

there may be several fore sights at a station, some in a forward and others in a backward direction. A sketch of the work of differential leveling is shown in Fig. 8. The form of notes is given in Problem B1.

To secure good results in leveling work the following points should be observed; first, the bubble should be in the center at every important sight; second, length of back sight and fore sight should be equal; and third, the rod should be held vertical.

Profile Leveling. Profile leveling consists in finding the profile of a certain line. Both the elevations above and the distances

from the initial point must be found. The method of procedure is similar to that of differential leveling, with the exception that sights are taken from one set-up of the instrument to several points on a given line. The maximum length of sight should not exceed 350 or 400 feet. It is, of course, impossible to have sights on all intermediate points, the same distance from the instrument. Ordinarily in differential leveling a target is set. The tendency at the present time in profile leveling is to use a self-reading rod with readings on bench marks and turning points to the nearest hundredth of a foot and on points on the line to the nearest tenth of a foot.

The detailed work of profile leveling is given in Problem B2, and the description of the plotting of the profile is given in Problems K1 and K2.

Establishing a Grade Line. After the profile has been obtained the grade line may be laid down on it. Among the points influencing the location of this grade line are: the maximum and minimum grades and the amount of cut and fill. The data concerning the grade line are noted, and the actual grade line may then be established in the field.

There are two methods commonly used to establish a grade line in the field. First, by determining the height of instrument, and then driving stakes so that their tops are at the required elevation. This is obtained by calculating the proper rod readings. Second, where a uniform grade extends between two points, the level may be set up over the first point and the height of the cross-wires above this point found. This height or distance may be laid off on a level-rod held at the second point, the cross-wires brought to it, and intermediate stakes found by setting their tops so that the cross-wires strike the center of the target. This is sometimes called " plunging a grade." The method is a rapid one, but great care should be taken that the line of sight does not leave the original foresight. See Problem B5.

Topographical Surveying. A topographical survey over a small area is sometimes made by splitting up the figure into squares or rectangles and obtaining the elevations of their corners. A detailed description of this work is given in Problem E3. This form of surveying is sometimes called *cross sectioning.*

Slope Stakes. The level may be used in railroad work at points where the side slopes intersect the surface of the ground. A complete description will be found in various railroad field books.

ADJUSTMENTS OF THE WYE LEVEL

In the Y level, the telescope rests in the Y's, and can be taken from them by loosening and raising the clips. For all practical purposes we may consider that the telescope rests on two points, one at each end of the telescope, and this line is called the bottom line of the Y's. Then by reference to Fig. 9, the principal elementary lines of the Y level are: (1) the line of collimation; (2)

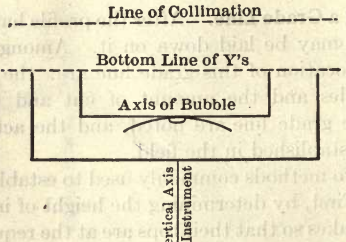


FIG. 9

the axis of the bubble; (3) the vertical axis of the instrument; and, for the purposes of adjustment, (4) the bottom line of the Y's; (5) a line joining the centers of the Y's, called the axis of the Y's. The adjustment of the Y level consists of the following:

I. To bring the axis of the bubble into the same plane as the axis of the telescope so that the bubble will remain in the center even though the telescope is turned slightly in the Y's.

II. To make the line of collimation parallel to the axis of the bubble, in order that the line of collimation may be horizontal when the bubble is in the center.

III. To make the axis of the bubble perpendicular to the vertical axis of the instrument, in order that the bubble may

remain in the center when the telescope is revolved around the vertical axis.

I. To bring the Axis of the Bubble into the same Plane as the Axis of the Telescope. Level up, loosen the clips, and turn the telescope through a small angle of 10° or 15°. If the bubble goes to one side, bring it *entirely* back by use of the capstan-headed screws on the side of the bubble tube. These screws are called the *azimuth* screws. Fig. 10 illustrates the adjustment. This adjustment is not of very great importance with the later makes of instruments, as the telescope is not free to turn in the Y's, being held in place by a pin in one of the clips, which fits into a notch cut into one of the rings on the telescope.

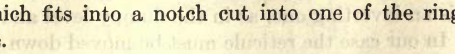


FIG. 10

II. To make the Line of Collimation Parallel to the Axis of the Bubble. This adjustment is made in two different ways: (1) by the *indirect* method, and (2) by the *direct* method.

(1) The *indirect* method consists *first*, of making the line of collimation (line 1) parallel to the bottom line of the Y's (line 4), in which case, assuming that the pivot rings which rest in the Y's are of equal diameter, in revolving the telescope in the Y's it will be the axis of a cylinder; but in case the pivot rings are not of the same diameter, due to wear, etc., it will be the axis of a cone, and will not be parallel to the bottom line of the Y's, and under these circumstances the method fails; and *second*, of making the axis of the bubble (line 2) parallel to the bottom line of the Y's. When these two things have been accomplished the line of collimation and the axis of the bubble will be parallel, since they are both parallel to the bottom line of the Y's.

To make the line of collimation parallel to the bottom line of the Y's. Set up the instrument and place a nail or mark a point on a fence or building at a distance of about 250 or 300 feet, at the point where the intersection of the cross-wires strikes.

Unfasten the clips, and having clamped the horizontal motion, turn the telescope over in the Y's (not end for end), and find whether the intersection of the cross-wires still strikes the point or not. Suppose that it does not, and that the intersection with respect to the horizontal wire strikes on the point A, Fig. 11, and the point B after turning the telescope over in the Y's. The correct position of the point of intersection is half-way between the two points, and the line of collimation must be brought to this point by changing the reticule. It is to be remembered that the reticule must be moved in a direction *opposite* to that which appears to be the right one, unless the telescope is an inverting one, as in the dumpy level and in some transits. In our case the reticule must be moved down (appears as if it must be moved up), and this is accomplished by loosening

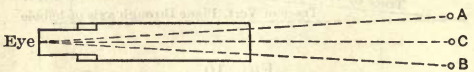


FIG. 11

the upper capstan screw and tightening the lower one until the intersection of the wires strikes the point C half-way between A and B. To do this each screw must be turned so that the *near* side moves to the right, the upper nut being of necessity moved first in this case as we wish to lower the reticule. The adjustment with respect to the vertical wire is made in a similar way, the side screws being the ones considered. Each part must be tested until it is known to be correct. The adjustment with respect to the horizontal wire is the more important.

It should be appreciated by the student that unless care is exercised in handling the instrument in this and in the following adjustments, the errors which appear are due to his own unskilful use of the instrument, and are not due entirely to the instrument's being out of adjustment.

To make the axis of the bubble parallel to the bottom line of the Y's. Having brought the telescope exactly over a pair of leveling screws, loosen the clips, and clamp the horizontal motion. Bring the bubble to the exact center by the use of the leveling

screws. Take the telescope out of the Y's, turn it end for end and replace it carefully. If the bubble runs to one end, that end of the tube is too high, and it must be lowered and the bubble brought half-way back. To do this the lower screw on the level tube must be loosened (by turning the near side to the left), and the upper one tightened. Bring the bubble the rest of the way back by the use of the leveling screws. Repeat the operation until it is correct. The screws at the top and bottom of the bubble tube are called the *altitude* screws. Fig. 12 shows why

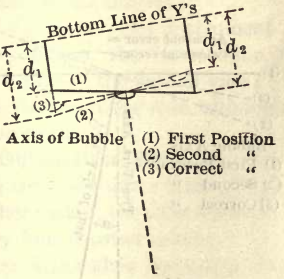


FIG. 12

the *apparent* error is twice the *real* error, and no further explanation is needed.

As previously stated, the above method of adjusting the line of collimation and the axis of the bubble depends upon the pivot rings being of the same diameter, in which case the line of collimation is the axis of a cylinder, and will be parallel to the bottom line of the Y's. In case they are not of the same diameter, this method fails, and the direct method must be employed.

(2) The *direct* method or "*peg adjustment.*" This method consists in adjusting the bubble directly to the line of sight. The indirect method is the one usually used with the Y level, but the "peg adjustment" must be used for the dumpy level and for the transit. This adjustment will accordingly be given with the transit adjustments entitled "*To make the axis of the telescope-bubble parallel to the line of collimation.*"

III. To make the Axis of the Bubble perpendicular to the Vertical Axis of the Instrument. The axis of the bubble has already been made parallel to the bottom line of the Y's, and the bottom line of the Y's must be made perpendicular to the vertical axis of the instrument. If this is done we can revolve the telescope around horizontally, and the bubble will remain in the center. The adjustment is simply one for convenience, as it does away with the necessity of releveling at every sight taken. The method of adjustment is as follows: Level the instrument over both sets of screws, and more carefully over

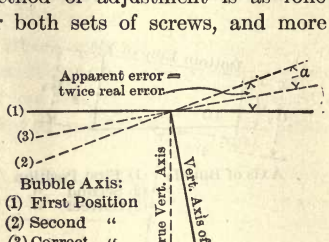


FIG. 13

the set where the telescope is left, and turn through 180° until over the same set of screws. If the bubble runs to one end bring it half-way back by the large capstan nuts at the bottom of the Y's, and the rest by the leveling screws. Remember that to lower one end of the line of Y's, and the end of the bubble at that Y, the upper screw must be *loosened* and the lower one *tightened*. Fig. 13 shows the position of the different lines, and requires no particular explanation.

ADJUSTMENTS OF THE DUMPY LEVEL

The main difference between the dumpy level and the Y level is that in the dumpy level the telescope cannot be taken from the Y's. There are then only the first three lines in the Y level. The two adjustments are as follows:

A. *Making the axis of the bubble perpendicular to the vertical axis of the instrument.* The principle of this adjustment is the same as II in the Y level, and is illustrated by Fig. 13. One-half the error is corrected in this case by raising or lowering one end of the level vial. (In the Y level, made by the large Y nuts.)

B. *To make the line of collimation parallel to the axis of the bubble.* These lines must be compared directly with each other by use of either one of the peg tests (Figs. 24 and 25), as on pages 73 to 76, and the *line of collimation* must be moved to be parallel with the axis of the bubble.

Centering the Eyepiece. An instrument may be in good adjustment and still have the intersection of the cross-wires appear out of the center of the field of view. If too far out, this will limit the area visible on one side, although it does not affect the accuracy of the work.

Centering the Object-glass Slide. In most makes of instrument no provision is made for the *field* adjustment of the object-glass slide. In other makes, the slide works through a ring which can be adjusted by four capstan screws.

The effect of the object-glass being out of adjustment is that the line of collimation will be correct for one length of sight, but not for others. In adjusting, the ring is moved until the intersection of the cross-wires is at best, when sighting on a far and on a near point.

The set of screws nearer the eyepiece is the one by means of which the eyepiece-barrel is centered, and these screws should not be disturbed in making other adjustments of the instrument.

PROBLEM B1. DIFFERENTIAL LEVELING

Equipment. Level, level-rod, turning point, hatchet, and crayon or keil for marking turning points.

Problem. *To find the difference in elevation of two points.*

Theory. For the principles underlying the work of leveling see pages 26–31.

Method. Set up and level the instrument so that a rod reading may be taken on the first point. It is to be noted that in leveling work the instrument need not be set exactly over any point, and

consequently the plate should always be made practically level before using the foot screws or leveling screws. The following points may be noted in this connection: Turn the telescope so that the bubble is parallel to one pair of leveling screws, and bring the bubble to the center, remembering that both thumbs turn out, or both in, and that the bubble will go in the direction in which the left thumb moves. Turn the telescope through 90° and level over the other set of screws. Care should be taken that the screws do not bind against the plate, but on the other hand, they should be brought snug against it, and not be too loose.

After taking a reading on the first point, have the rodman select a suitable turning point in advance and take a reading on it. This completes the work at a set-up and the instrument is carried forward, and so on until the last point is reached. If absolute elevations are not desired, the first rod reading taken at each set-up of the instrument may be placed in one column, and the second in another; the columns may be summed, and one sum subtracted from the other will give the difference in elevation of the points. A check on the field work may be found by completing the circuit, in which case, the difference between the sums of the columns should be equal, and if they are not, this difference is the error in the circuit.

If elevations of the points are desired, the notes are kept as in the form below. As previously explained, the height of instrument (H.I.) is found by adding the first rod reading to the elevation of the first point. The elevation of the turning point is found by subtracting the reading taken on it from the H.I. The first sight taken at each set-up of the instrument is called a plus sight (+ S) or a back sight (B.S.); the reading taken in order to determine the elevation of a point is a minus sight (− S) or a fore sight (F.S.). It is to be noted that these words do not refer to the direction of the sights, but that the first sight taken to a point of known elevation is always a plus or a back sight, and that several minus sights may be taken from any set-up.

As applied to differential leveling, there are as many back sights as fore sights. In profile leveling (Problem B2), a large number of intermediate sights (I.S.) are taken. These sights

are fore sights, but for purposes of checking are kept in a special column.

In order to secure good results in leveling, the following points should be observed; the length of sights should not be more than 350 ft.; the length of back and fore sights at a set-up should be equal. In using the level, see that the bubble is in the center and then set the target, the rod being held plumb. Clamp the target, check its position by again looking through the telescope, and finally, see that the bubble is in the center. The level man checks the reading while passing the rodman, and it is then recorded.

PROB. B1. DIFFERENTIAL

+S	H.I.	-S	I.S.	Elev.	Sta.
6.629	106.629			100.00	B.M.1
4.833	108.026	3.436		103.193	T.P
0.669	102.183	6.512		101.514	T.P.
1.170	92.574	10.779		91.404	T.P.
1.636	84.346	9.864		82.710	T.P.
9.952	82.881	11.417		72.929	B.M.2
11.616	93.176	1.321		81.560	T.P.
8.944	100.970	1.150		92.026	T.P.
6.360	105.411	1.919		99.051	T.P.
		5.421		99.990	B.M.1
51.809		51.819		100.000	
		51.809		99.990	
		0.010	Check	0.010	

LEVELING

B.M.1 – East small nut of Hydrant at N.W. corner of Elm and Sever Sts.

Oct. 16, 1911. C.F. Clarkson, Levelman.
A.G. Cranford, Rodman.
C.L. Francis, Note-keeper.

B.M.2.– Property monument at S.E corner of Fourth and Poplar Sts.

Equipment:- Level No.6. Hatchet No.4. Level-rod No.14. Turning point No.6.

B.M.1 – As above.

PROBLEM B2. PROFILE LEVELING. (DRAIN.)

Equipment. Level, self-reading level rod, steel tape, turning point, hatchet and keil.

Problem. *To determine the profile for a drain.*

Method. Select a location suitable for a drain. Stake out the line with stakes every 50 feet or oftener, in order to get a good profile. The method of procedure is practically the same as that employed in differential leveling, except that sights, called intermediate sights (I.S.) are taken on several stations from one set-up of the instrument.

After taking the profile of the line, complete the circuit to the original bench mark (B.M.). As to length of sights, the same precautions should be observed as in the previous problem. It is advised that intermediate bench marks be left at quarter mile intervals, always leaving a B.M. near the end of the line.

Remark. In the notes given for this problem a target rod was used and readings on bench marks and turning points taken to thousandths, the object being to give additional practice in using the target. Ordinarily, the nearest hundredth on these points and tenths on intermediate sights would be sufficient with corresponding elevations.

Plotting the Profile. The profile may be plotted in connection with this problem, or as a special office problem. Complete directions for plotting are given in Problem K1.

PROB. B2. PROFILE

+S	H.I.	-S	I.S.	Elev.	Sta
0.767	100.767			100.000	B.M.1
			0.2	100.57	0+00
			4.1	96.67	+50
			8.1	92.67	1+00
0.495	91.542	9.720		91.047	T.P.
			4.6	86.94	+50
			9.9	81.64	2+00
1.275	82.935	9.882		81.660	T.P.
			5.1	77.84	+50
0.625	73.898	9.662		73.273	T.P.
			3.8	70.10	3+00
			9.9	64.00	+38

And so on to B.M.2 and return, applying check as in Prob. B1.

LEVELING - DRAIN.

Oct. 23, 1911.

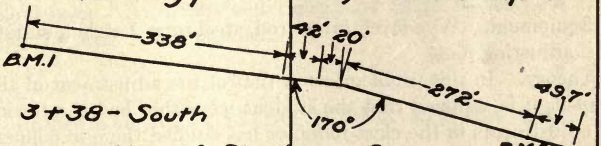
B.M.1 - Drill hole in first step at North basement door of Stephens Hall.

S.A. Cranston, Levelman.

W.C. Stall, Rodman.

G.C. Carpenter, Notekeeper

Equipment - Level No. 6, Level-rod No. 4, Range poles Nos. 7 and 14, Tape No. 9, Hatchet No. 14, Bob No. 26, Turning point No. 8, Stake strap No. 1.



PROBLEM B3. PROFILE LEVELING. (STREET.)

Equipment. Level, self-reading level rod, steel tape, turning point, hatchet and keil.

Problem. *To determine the profile of the center line of a street; either curb line; or all three.*

Method. Establish the center line of the street, and mark points every fifty feet apart. In case of a curb line, mark the stations by keil or crayon.

Starting from a bench mark, either of a given elevation or an assumed one, run a line of levels over the points in an entirely similar way to that described in Problem B2.

Readings should be taken on all points where there are changes of grade. Also readings should be taken at the intersection of the corresponding lines of cross streets, and the stations of these points noted. See Problem K2 for an illustration.

Notes. The form of notes is similar to that in Problem B2.

Profile. The profile may be plotted in connection with this problem or as a special office problem. Complete directions for plotting are given in Problem K2.

PROBLEM B4. ADJUSTMENTS OF THE WYE LEVEL

Equipment. Wye level, target rod, steel tape, hatchet, stakes, and adjusting pins.

Theory. In this problem, as in that of the adjustment of the transit, it is assumed that the student has either had the theory of adjustments in the class room, or has studied them in connection with pages 32 to 37. The description in these problems will accordingly be abridged. References will be made, however, to the pages above mentioned.

Method of Making the Adjustments with Form of Notes. It is recommended that in a course given for mechanical and electrical engineers, the instrument be only tested for adjustments. With civil engineering students, it is hoped that the equipment will allow of the actual adjustments being made.

With the former, the condition of the instrument in all particulars may be noted, with a statement of the method of making

each adjustment if the adjustments are necessary. With the civil engineering student, state not only the condition of the instrument, but how each adjustment is made.

To bring the axis of the bubble into the same plane as the axis of the telescope. See page 33. Turn the telescope in the wyes through a small angle and note the movement of the bubble in divisions or in fractions of an inch. State how it was or could be corrected. Give a sketch similar to Fig. 10 on page 33.

To make the line of collimation parallel to the axis of the bubble. See page 33 for the indirect, and page 73 for the direct method.

For the first part of the indirect method note the amount that the line of collimation was out, illustrating by sketch similar to Fig. 11 on page 34, and for the second part of the indirect method, note the movement of the bubble in divisions of scale at each test.

If the direct method, or "peg adjustment," is used, illustrate by suitable sketch giving all rod readings, including the correct rod reading for making the adjustment.

To make the axis of the bubble perpendicular to the vertical axis of the instrument. Note in the field book the movement of the bubble when the telescope was turned 180° around the vertical axis. State how the error was or could be corrected. See Fig. 13 of page 36. Give equipment, party, date, etc., on right-hand page. Both left- and right-hand pages of the note book may be used in this problem.

PROBLEM B5. LAYING OUT A SIMPLE GRADE

Equipment. Level, self-reading level-rod, 100-ft. steel tape, hatchet, stakes, and keil.

Problem. *To set grade stakes for a curb line, or for reballasting an old line of railroad, or for the center line of a new road.*

Theory. If the elevation of grade and ground are known at a given station, the difference of elevation can be obtained and marked on the grade stake, or, if it be desired to put the top of the grade stakes at grade, as in the case of ballasting, this can be done if the H.I. is known.

Method. This problem will consist of two parts: First, to lay out the simple grade, and second, to check the marking of the stakes by plunging the grade.

Simple grade. Run out a line from 200 to 400 feet in length, placing stakes 20 to 50 feet apart. Set the instrument up at the side of the line about midway between the end stakes and take a rod reading on a B.M. (either actual or assumed). Take rod readings on the ground at the base of each stake. Assume the elevation of grade at the first station, and a rate of grade. Then the grade elevation at any other station may be found. The difference between grade and surface elevations will give the cut or fill at the point. Take a rod reading on the top of each stake and find its elevation. Lower the stake until the cut or fill from its top is an even foot or an even foot and tenth of foot.

Mark the cut or fill for top of the stake. In the notes of this problem the fill is given in inches instead of tenths of feet. This method is quite common, since many contractors do not understand the meaning of tenths.

Plunging a grade. Set up over the first stake and place a pair of leveling screws in line with the stakes.

Let a be the height of the cross-wires above grade at this station. In the given problem this value is 4.11.

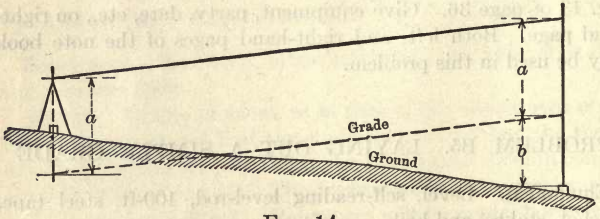


FIG. 14

Place the level rod on the top of the stake where the grade changes, and with the target set at $a \pm b$ bring the cross-wires to this reading by changing the leveling screws, where b = the difference of elevation between the grade and the top of the second stake. In the given problem, the second point is 3″ below grade and $a \pm b$ or the rod reading necessary to locate a grade line parallel to the given grade will be $4.11 + 0.25 = 4.36$.

Take rod readings on the intermediate stakes, and find the cuts or fills by applying these readings to the value of 4.11. Finally, compare these cuts or fills with those obtained in the first part of the problem and note the difference between the two methods.

The student should be able to solve other cases as they may arise.

PROB. B5. LAYING OUT A SIMPLE GRADE AND PLUNGING A GRADE.

Sta. (Notes extend across both pages)	+S.	H.I.	-S	Ground	Grade	Cut or fill on ground	Elev. top of stake	Cut or fill top of stake Inches
B.M.	.18	100.18		100.00				
0+00			0.76	99.42	100.00	- .58	100.00	0"
+20			2.03	98.15	99.50	-1.35	98.75	- 9"
+40			2.83	97.35	99.00	-1.65	97.75	-15"
—								
1+80			6.11	94.07	95.50	-1.43	94.50	-12"
2+00			5.89	94.29	95.00	- .71	94.75	- 3"

Plunging the Grade

Sta.	+S	H.I.	Rod Read. for Grade	Rod Read. top last Stake	Rod Read. Interm Stake	Cut or fill top of stake	Diff. bet. two methods	
0+00			4.11			0.00	.00	
+20					4.85	- .74	.01	
+40					5.35	-1.24	.01	
+60					5.85	-1.74	.01	
—								
1+60					5.60	-1.49	.01	
1+80					5.10	- .99	.01	
2+00				4.36		- .25	.01	

PROBLEM B6. VERTICAL CURVE

Equipment. Level, self-reading level rod, tape, hatchet, stakes, and keil.

Problem. *To connect two grades by a vertical curve.*

Theory. The curve which is most commonly used for connecting two grades is the parabola, and the notation used in the case of the simple curve as respects *P.C.*, *P.T.*, and *P.I.* may be applied to the vertical curve.

Assuming the origin of coordinates at the *P.C.*, the offsets from the tangent to the curve vary as the squares of the distances from the *P.C.*

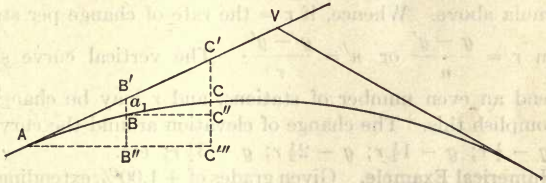


FIG. 15

In Fig. 15, the offset a_1 at the first station equals $\frac{g - g'}{2n}$, where g equals the first grade and g' equals the second grade and n equals the length of the vertical curve in stations. The offset at the second station equals $4a_1$, at the third station $9a_1$, etc. Theoretically, the measurements should be made along the tangent and at right angles to the tangent, but there is no practical error for ordinary grades by making the measurements horizontally and vertically.

The elevation of points on the vertical curve may be computed in one of the following ways: First, compute the elevations of points on the tangent and apply the offsets a_1, $4a_1$, etc., giving them the correct sign. Second, find the elevations of the points *B*, *C*, etc., above the horizontal line AC'''. Third, find the elevation of *B* above *A*, *C* above *B*, etc. The length of the vertical curve depends upon the rate of change of grade. In

general, vertical curves in sags should be longer than those at summits.

It is preferable to have the intersection of the grades come at an even station, but if this is impossible the offsets at equal intervals from the *P.I.* may be computed. Where the even stationing is used, the offsets at the even stations are found by multiplying a_1 by the squares of the distances in stations from the *P.C.* or *P.T.* The length of the vertical curve recommended by the American Railway Engineering Association depends upon the class of traffic, and whether on a sag or on a summit. The rate of change per station is from 0.05 to 0.20. On mountain roads it may sometimes seem necessary to exceed these values.

The "rate of change per station" corresponds to $2\,a_1$, in the formula above. Whence, if r = the rate of change per station, then $r = \dfrac{g - g'}{n}$ or $n = \dfrac{g - g'}{r}$. The vertical curve should extend an even number of stations, and r may be changed to accomplish this. The change of elevation around the curve will be $g - \frac{1}{2}r$; $g - 1\frac{1}{2}r$; $g - 2\frac{1}{2}r$; $g - 3\frac{1}{2}r$; etc.

Numerical Example. Given grades of $+1.00\%$ extending from station 15 with elevation of 112.00 to station 120 and then by a $+0.6\%$ grade to station 125. Assuming $r = 0.10$ per station, find n and the elevations of points on the vertical curve.

Ans. *P.C.* of vertical curve = Sta. 8; *P.T.* = Sta. 12; elevations of the stations on the curves starting with that of *P.C.* are 115.00, 115.95, 116.80, 117.55, 118.20.

Method of Staking-out in the Field. The method of procedure is similar to that given in Problem B5. The stakes are placed 20 to 100 feet apart. The elevations of the grade and ground are found with respect to a given datum and the cut or fill marked on the center stakes. The elevations of the successive points, instead of changing by a constant amount, as in a simple grade, change by a variable amount, as determined above.

Form of Notes. The form of notes is similar to that given in the first part of Problem B5, Simple Grade. Brief computations for determining the elevations of points on the vertical curve may be preserved on the right-hand page of the field book.

CHAPTER IV

THE COMPASS

The surveyor's compass consists of a line of sight attached to a horizontal graduated circle, at the center of which is a magnetic needle free to move on a pivot. Both the compass box and sights are supported by a jacob staff or a tripod. With the former, the leveling is accomplished by means of a ball and socket joint, or a leveling base, as in the level.

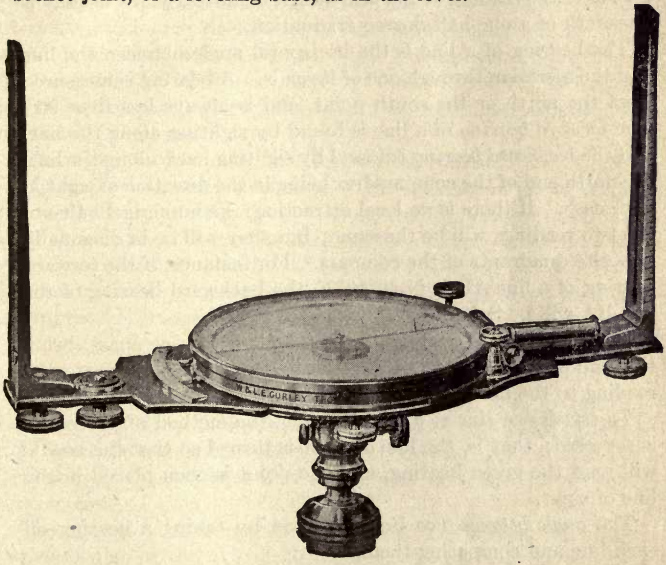


FIG. 16. The Vernier Compass

In some instruments there is a tangent screw and a vernier scale for setting off the declination of the needle, and on the edge of the vertical sights there is a tangent scale for reading the vertical angles.

The E. and W. on the compass box are reversed in position, due to the fact that the graduated circle is attached to the line of sight, and moves with it, while the needle is stationary.

Use of the Compass. The compass is used: (1) to determine the bearing of a line; (2) to establish a line of a given bearing; (3) to measure the angle between two lines; (4) to retrace old lines.

The following points may be noted in using a compass; always have the north end of the compass box along the line and read the north end of the needle, which is the end without the brass wire. Estimate the reading to the nearest five minutes, which usually is one-sixth of a one-half degree graduation.

The bearing of a line is the horizontal angle between the line and the meridian through one of its ends. A bearing is measured from the north or the south point, and is always less than 90°. The *forward bearing* of a line is found by sighting along the line, and the *backward bearing* is found by sighting back along the line, the north end of the compass box being in the direction of sight in each case. If there is no local attraction, the numerical value of the two readings will be the same; but they will be in diagonally opposite quadrants of the compass. For instance, if the forward bearing of a line AB is N 40°10′ E, the backward bearing of the line BA will be S 40°10′ W.

To determine the bearing of a line, set up the compass, bring the line of sight to coincide with the given line, and note the reading to the nearest five minutes.

To establish a line of a given bearing, the method of procedure is reversed; that is, the line of sight is turned so that the needle will read the given bearing, and the point is then placed in the line of sight.

The *angle between two lines* is found by taking a bearing on each line and comparing them.

In retracing an old line, set the compass over one point in the line and make the line of sight coincide with the line. Read the bearing. If it does not agree with the given bearing, the difference of the two bearings may be used as a correction to be applied to the other lines of the area.

Declination of the Needle. The declination of the needle is the horizontal angle it makes with a true meridian. This angle

varies, and its change is called the *variation* of the declination. *Isogonic lines* are imaginary lines joining points on the earth's surface having the same declination at any given time. The isogonic line joining points of zero declination is called the *agonic line.*

Variations of Declination. There are many kinds of variations of the magnetic needle, the two principal ones being the *secular* variation and the *daily* variation.

The *secular variation* is of a periodic character and requires two or three centuries to complete its cycle. The practical result of this variation in declination is that the declination at any given point changes from year to year. Observations have been made by the United States Coast and Geodetic Survey at many points in this country, and the results of their observations are published from time to time.

The *daily variation* in the declination consists of a slight swinging of the needle each day. This movement varies from ten to twelve minutes a day. It is at a *mean* position at about 10.30 A.M. and 8.00 P.M., and is at its extreme easterly and westerly positions at about 8.00 A.M. and 1.30 P.M., respectively. The amount of this variation is given in Table VII and a further explanation of its use in Problem C2.

ADJUSTMENTS OF THE COMPASS

The adjustments of the compass may be divided into two parts; first, those which are looked after by the maker, and which cannot well be made outside the factory; and second, those that may be made by the surveyor and which may need attention from time to time.

The makers adjustments should include: (1) making the plate perpendicular to the axis of the socket; (2) making the line of sight pass through the zero points of graduation.

The effect of (1) is that the plate may become bent and it would then be impossible to keep the plate levels in the center. The effect of (2) is that the bearings of lines taken would not be correctly referenced.

The ordinary adjustments are: (1) to make the plane of the plate bubbles perpendicular to the vertical axis of the compass;

(2) to make the plane of sights normal to the plane of the plate bubbles; (3) to make the two ends of the needle read 180° apart; (4) to remagnetize the needle.

Principle of Reversion. The principle of *almost all* instrumental adjustments is the *principle of reversion*, whereby the error is *doubled* and *made apparent.*

Adjustments. 1. *To make the plane of the plate bubbles perpendicular to the vertical axis of the compass.* Level the instrument in one position, turn 180°, and if the bubbles move from the center, correct one-half the movement of each bubble by adjusting screws at the end of each bubble-tube. The remainder of the movement may be made by releveling. Repeat the test until the bubble remains in the center for all positions of the plate. If the plane of the plate is not bent, the plane of the bubbles will be parallel to the plate.

For a diagram illustrating this adjustment, see Fig. 13 of page 36.

2. *To make the plane of the sights normal to the plane of the plate bubbles.* Level the instrument and bring the plane of the sights upon a vertical line; such as the edge of a building, or a long plumb line. If this line appears to traverse the slit in the farthest sight, then that sight is in adjustment. Reverse the instrument and test the other sight. If either sight is out of adjustment, one side of the base may be filed off, or a thin piece of paper may be inserted under the other side.

3. *To make the two ends of the needle read 180° apart.* If the two ends of the needle do not read 180° apart, it may be due either to (*a*) the needle being bent, or (*b*) to the pivot being bent, or (*c*) to both causes.

To straighten the needle, set its north end at zero and bend the south end so that it also reads zero. Repeat the operation until the work checks.

To adjust the pivot. If the pivot is bent, the difference between the two end readings is variable for different parts of the circle. Find the position of the needle which gives the maximum difference of end readings. Bend the pivot at right angles to this position by one-half the difference of the end readings. Repeat the work until it gives a satisfactory check.

4. *To remagnetize the needle.* Remove the needle from the pivot. Take a bar magnet and rub each end of the needle, from the center towards the ends, with the end of the magnet which attracts in each case.

Local attraction. The needle is affected by proximity of substances composed of iron or steel, such as: wire fences, mineral deposits, railroad rails, steel hat bands, etc. In order to correct for local attraction, the backward and forward bearings of all lines should be taken. If they agree, it shows that no local attraction exists.

PROBLEM C1. COMPASS SURVEY OF A HEXAGON

Equipment. Surveyor's compass, steel tape, two range poles, hatchet, set of marking pins, and stakes.

Problem. *To make a survey of a hexagon by use of a compass and tape.*

Method. Drive six stakes, forming a hexagon with sides from 200 to 400 feet in length. Set the compass up over one station and make two independent readings of the bearings of lines AB and AF. Make these readings by estimating to the nearest five minutes. Set up at Station B and take two readings of the backward bearing of the line BA and of the forward bearing of the line BC. Continue around the figure to the starting point.

In taking the bearing of a line, the north end of the compass box should be sighted along the line, and the north end of the needle should be read.

At convenient times during the progress of the work, the chainmen should make two measurements of the length of each line, recording the mean in each case.

Computations. Place the mean of the two compass readings of each line in the fourth column of the table given below, and compute the angle at each station, using only the bearings of the lines as measured from that station. By use of these angles the corrected bearings of the lines are computed, starting with a line whose forward and backward bearings agree numerically, or nearly so, and working each way. At the junction, the forward

and backward bearing of a line should differ by the angular error of closure.

Compute the latitudes and departures of the courses, the error of closure, and the area. For a description of these terms and methods of computation, see pages 143 to 146.

Remark. An actual field may be used for this problem. In case the sides of the field are obstructed, a traverse line may be run either inside or outside the boundary line, and each corner of the field tied in to a compass station by a bearing and a distance. The area within the traverse lines may be found as in the problem below, and the additional areas added or subtracted as the case may be. It is recommended that in such a survey, the form of notes include both a tabular form and a sketch.

PROB. C1. COMPASS SURVEY

Line	1st. Read.	2nd Read.	Mean Read.	Angle	Dist.
AB	S84°30'W	S84°20'W	S84°25'W		247.8
AF	N59°40'E	N59°50'E	N59°45'E	155°20'	
BC	N21°30'W	N21°40'W	N21°35'W		135.1
BA	N84°10'E	N84°15'E	N84°12'E	105°47'	
And so on			Sum of Angles	719°55'	
			Error	0°05'	

OF A HEXAGON.

Party, date, equipment, etc. as usual.

Sides.	Calc Bearing	Latitude +	Latitude −	Departure +	Departure −
AB	S84°25'W		24.11		246.63
BC.	N21°22'W	125.49			49.22
And so on					

Error of closure = $\frac{\sqrt{\text{Error Lat.}^2 + \text{Error Dept.}^2}}{\text{Perimeter}}$

PROBLEM C2. DECLINATION OF THE MAGNETIC NEEDLE

Equipment. Surveyor's compass, or transit, and range pole.

Theory. The magnetic declination at any point is the horizontal angle between the magnetic meridian and the true meridian. The declination is subject to various changes, the principal of which are: the secular variation, and daily variation. Only the daily variation is here considered.

The needle is in its mean daily position at about 10.30 A.M. and 8.00 P.M. The range of movement extends from about five minutes in winter to nearly twelve minutes in summer. There is a slight change with the latitude. The correction to be applied to the mean declination is given in Table VII.

Method. Set up and carefully level the compass over the south end of a true north and south line which has been previously determined; or over one end of a line whose true bearing is known. This line should be located at a distance from any source of magnetic disturbance, such as trolley wires, etc. When the compass has a declination arc, with the north end of the compass box along the meridian, bring the needle to a zero reading, by use of the tangent screw of the declination arc. Note the reading on the declination arc and the time of observation to the nearest minute. When a transit is used, the plates are first set at zero, and after the telescope has been brought on the true meridian, the lower motion is clamped. The upper clamp is then loosened and the plate turned so that there is a zero reading of the needle. In either instrument the direction of the declination should be noted; for example, when set up over the south end of the true meridian, if the needle is west of north, then the declination is west; but the magnetic bearing of the true north and south line is northeast. Make at least ten independent observations, and find the mean reading of the declination arc or reading on transit plate, and the mean time corresponding to this mean reading. Apply the hourly correction to this mean reading as given in Table VII.

PROB. C2. DECLINATION OF

Number	Mag Bearing	Mean Bearing	Time	Mean Time
1	N40°28'E		2-00 P.M.	
2	N40°27'E		2-05 "	
3	N40°28'E		2-10 "	
—				
—				
—				
39	N40°19'E		5-15 "	
40	N40°20'E	N40°21'E	5-20 "	3-40 P.M.

THE MAGNETIC NEEDLE.

June 17, 1914

E.L. Jones, Observer

Equipment - Transit No. 14

True Bearing of Line Used = N 26°45'E

Mean Magnetic Bearing = N40°21'E

Approximate Declination = 13°36'W

Correction from Table VII = 0°04'W

Magnetic Declination = 13°32'W.

PROBLEM C3. ADJUSTMENTS OF THE COMPASS

Equipment. Surveyor's compass and adjusting pin.

Method. See pages 53 to 55 for a more complete description of this work. First, test the adjustment for making the plane of the plate bubbles perpendicular to the vertical axis of the instrument. If the bubbles are out, adjust them.

Second, test the adjustment for making the plane of the sights perpendicular to the planes of the plate bubbles.

Third, test the readings of the needle and determine whether the needle or the pivot is bent.

Report. Briefly describe the method of making each test, with statement of what should be done in case any part of the compass is out of adjustment.

CHAPTER V

THE TRANSIT

The engineer's transit consists of an *alidade* carrying the line of sight, and attached to an inner solid spindle which turns in an hollow outer spindle. The outer spindle carries the horizontal graduated circle (called the *limb*) and may revolve in the outer socket which is attached to the leveling head. The alidade includes the telescope, the compass box, needle, vertical circle or arc with its vernier, and the vernier to the horizontal circle. The alidade may be revolved, while the limb is clamped to the lower part of the instrument; it may be clamped to the limb and the whole upper part of the instrument revolved in the outer socket.

Horizontal angles may be measured by clamping the lower motion, sighting the telescope at a point, reading the vernier, and then unclamping the upper motion, sighting at a second point, and again reading the vernier. The difference between the readings will give the value of the angle. The construction of the transit may be studied from the cross-section in Fig. 18.

In the common form of transit the limb is graduated to degrees and half degrees, and is numbered from 0° to 360° preferably in both directions. The numbers are slightly inclined in opposite directions.

The engineer's transit is sometimes called the "universal surveying instrument," inasmuch as it can be used for the measurement of distances (with stadia wires), for leveling (with the telescope bubble and vertical circle), and for horizontal angles.

The Telescope. The transit telescope does not differ materially from the level telescope. The magnifying power is not as great. In the engineer's transit there are two additional horizontal cross-hairs, called stadia hairs, on the reticule.

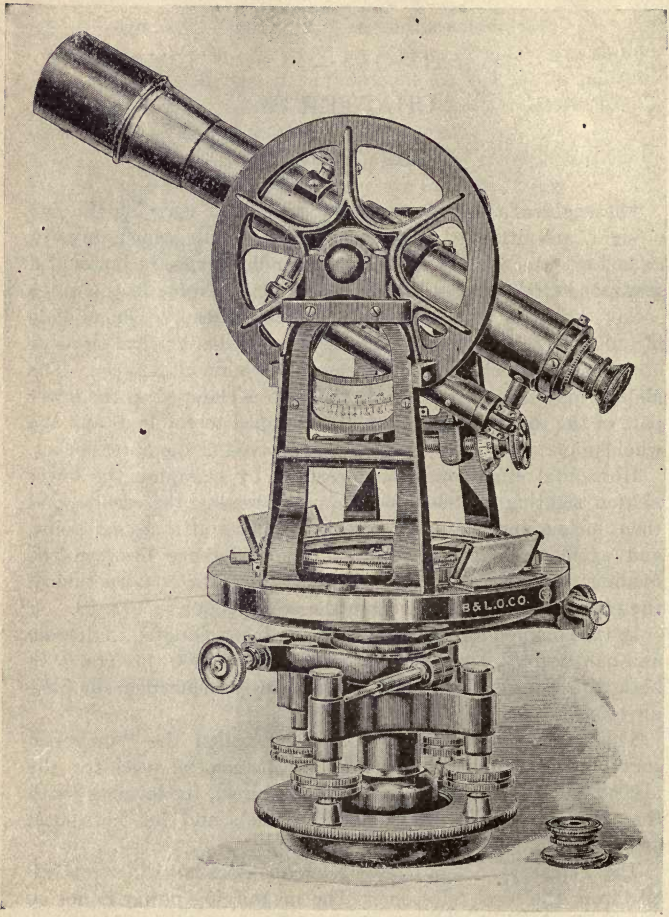


FIG. 17. The Engineer's Transit

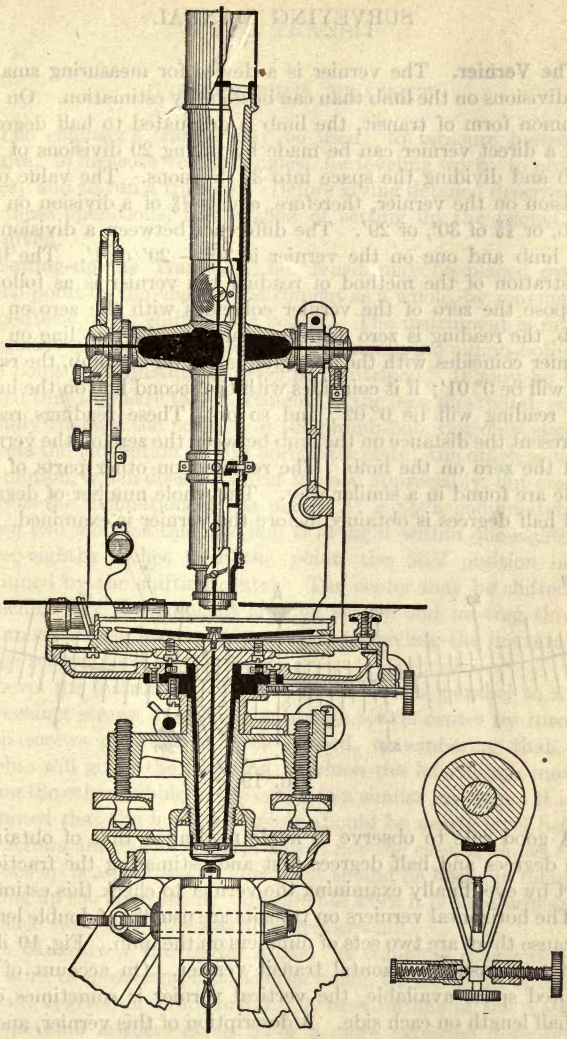


FIG. 18. Section of the Transit

The Vernier. The vernier is a device for measuring smaller subdivisions on the limb than can be done by estimation. On the common form of transit, the limb is graduated to half degrees, and a direct vernier can be made by taking 29 divisions of the limb and dividing the space into 30 divisions. The value of a division on the vernier, therefore, equals $\frac{29}{30}$ of a division on the limb, or $\frac{29}{30}$ of 30′, or 29′. The difference between a division on the limb and one on the vernier is 30′ − 29′ or 1′. The best illustration of the method of reading the vernier is as follows: suppose the zero of the vernier coincides with the zero on the limb, the reading is zero degrees. Suppose the first line on the vernier coincides with the first graduation on the limb, the reading will be 0° 01′; if it coincides with the second line on the limb, the reading will be 0° 02′, and so on. These readings really represent the distance on the limb between the zero on the vernier and the zero on the limb. The readings on other parts of the scale are found in a similar way. The whole number of degrees and half degrees is obtained before the vernier is examined.

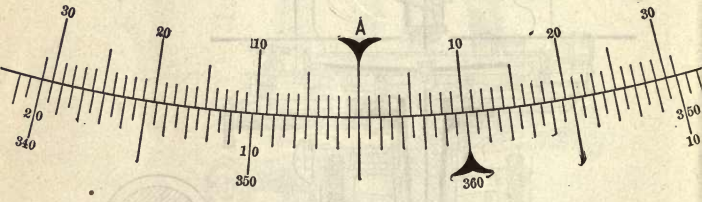


FIG. 19

A good rule to observe in angle reading is that of obtaining the degrees and half degrees first and estimating the fractional part by eye, finally examining the vernier to check this estimate.

The horizontal verniers on transits are usually of double length because there are two sets of numbers on the limb. Fig. 19 illustrates the usual horizontal transit vernier. On account of the limited space available, the vertical vernier is sometimes only of half length on each side. A description of this vernier, and an outline of the method of reading is given on page 66.

USE OF THE TRANSIT

The engineer's transit may be used: to measure horizontal angles; to measure vertical angles; for leveling work; to prolong lines; and to run a traverse. Before giving detailed descriptions of these operations, the method of setting up the transit will be given.

Setting-up the Transit. The transit may be placed over a given point by moving the instrument as a whole, by moving the tripod legs or by shifting the center. The instrument is moved so that it is nearly over the station, bringing the plumb-bob over the point by adjusting the legs of the tripod. It may be here noted that there are two movements of the legs, one radial, which rapidly changes the position of the plumb-bob, but only slightly affects the inclination of the horizontal plate; the other, a circular motion, which does not affect the bob appreciably, but greatly affects the inclination of the plate. It is by a combination of these two motions that the bob is brought within one-eighth to three-eighths inches from the point, the final position being obtained by the shifting center. The center may be shifted by loosening any two adjacent leveling screws and moving the instrument on the leveling plate. Before leveling the instrument, these screws must be tightened.

Level the instrument by placing a level vial parallel to a set of leveling screws, bringing the bubble to the center by turning both screws outward or both inward, remembering that the bubble will go in the direction in which the left thumb moves. Bring the other bubble to the center in a similar manner. It is to be noted that the horizontal plate should be nearly level before the screws are touched, and if this is not the case, it shows that the set-up is a poor one. This point should be borne in mind in setting up the instrument. On side hill work it is often advisable to place two legs of the instrument down hill.

To Measure a Horizontal Angle. A complete description of the work of measuring a horizontal angle, by use of an ordinary transit, is given in Problem D1. A brief outline of the method of repetition is there given. For a more extended description of the method of repetition and the method of measuring an angle

by use of a triangulation transit, reading by micrometer screws to seconds, the reader is referred to textbooks on higher surveying.

To Measure a Vertical Angle. The vertical angle is the angle of depression below, or of elevation above, the horizon. The horizon is determined by the axis of the long bubble attached to the telescope. When this bubble is in the center, and when the horizontal plate is level, the reading on the vertical circle should be zero. If it is not zero, a correction called an " index error " should be applied to all the readings.

The vertical angle from the transit station to the point of observation may be found by bringing the horizontal wire into coincidence with the object. The vertical circle is then read, and the index error, if any, is applied. If there is a complete vertical circle on the transit, the telescope may be reversed and the vertical angle again read. The average of the two readings will give the true value of the angle, the index error being eliminated.

Vernier on Vertical Circle. On account of lack of space, the vernier on the vertical circle is sometimes of half length only, on each side. Many of the older transits have this form of vernier, but the present tendency is to spread the standards, thus securing the necessary space for the full double vernier. This short vernier is sometimes of the *retrograde* form. In such case there is one *less* division on the vernier than there are divisions on the scale. Fig. 20 shows a direct vernier. In 1 of that figure the zeros coincide, and it can be proved that the vernier reads to minutes.

The reading of 2 in Fig. 20 is 7° 50′. The zero of the vernier is to the *left* of 7° 30′ on the scale, but the additional 20′ is obtained to the *right* of the zero of the vernier or backward. The suggestion previously given, that the reading be guessed, then checked by use of the vernier, is decidedly appropriate with this form of vernier.

Use of the Transit as a Level. The engineer's transit instead of a level may be used for leveling work. In leveling the instrument, the plate levels are first brought to the center, and the telescope bubble is then brought to the center by the clamp and tangent screw. The telescope is then turned 180° in azimuth, and if the long bubble runs out, it is brought half-way back by

the tangent screw on the telescope and the remainder by the leveling screws. This operation is repeated over both pairs of leveling screws until the bubble remains in the center upon a

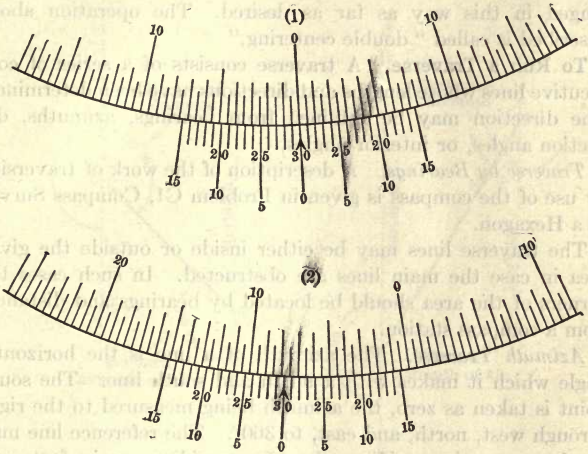


FIG. 20

complete revolution. The long telescope bubble, being more sensitive than the plate levels, will show slight changes in elevation more rapidly.

For rapid leveling, the plate levels may be brought to the center and if the telescope bubble is in the center at each sight taken, the results will be correct.

To Prolong a Line. Where the line is to be prolonged for a short distance only, the transit may be set up over the rear station, a sight taken at the forward station, and a point placed on line beyond the forward station. Where the distance is great, the transit is set up at the forward point and a back sight is taken on the rear station. The telescope is plunged, and a forward point marked. The telescope is then revolved in azimuth, a sight is again taken at the first point, and after plunging the telescope,

a second forward point is marked. The two points will coincide if the instrument is in adjustment, but if not, a mark half-way between the two points will be in a straight line. The transit may then be carried forward to this new point, and the line prolonged in this way as far as desired. The operation above described is called "double centering."

To Run a Traverse. A traverse consists of a series of consecutive lines whose lengths and directions have been determined. The direction may be obtained from bearings, azimuths, deflection angles, or interior angles.

Traverse by Bearings. A description of the work of traversing by use of the compass is given in Problem C1, Compass Survey of a Hexagon.

The traverse lines may be either inside or outside the given area in case the main lines are obstructed. In such cases the corners of the area should be located by bearings and distances from a compass station.

Azimuth Traverse. The azimuth of a line is the horizontal angle which it makes with a north and south line. The south point is taken as zero, the azimuth being measured to the right through west, north, and east, to 360°. The reference line may be the magnetic meridian, the true meridian, or in fact, any line. A line has a forward and a backward azimuth. They differ by 180°. In 1 of Fig. 21, the forward azimuth of the line AB is the angle from the south point clockwise to the line, in this case 135° 06′. The backward azimuth of the line is the direction of BA from the south point, in this case 315° 06′. In 2 of Fig. 21, the forward azimuth of AB is 210° 14′ or more than 180°. The backward azimuth of BA is 30° 14′.

From these facts arise two common rules: first, if the forward azimuth of a line is less than 180°, the backward azimuth is found by adding 180° to the forward azimuth; and second, where the forward azimuth is greater than 180°, the backward azimuth is found by subtracting 180° from the forward azimuth.

The field work of making an azimuth traverse is as follows: set up the transit at the first point, and with vernier A at zero, turn the telescope until the north end of the needle reads magnetic south. Clamp the lower motion and sight on the second

station reading the azimuth and the magnetic bearing of the line. Sight along the last line of the figure, securing its azimuth and bearing. If the distances are to be obtained by the stadia,

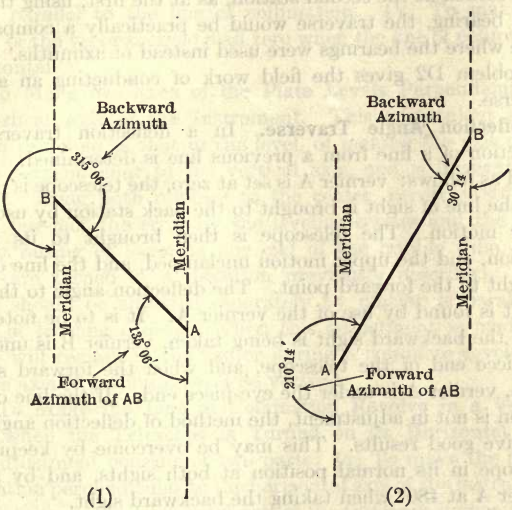


FIG. 21

the intercepts on the rod and the vertical angles should be obtained. (See pages 91 to 94 for the theory of the stadia, and Problem E2 for traversing by the stadia.)

The instrument is then set up at the second station, the backward azimuth of the line is laid off by the use of vernier A, and by use of the lower motion, the telescope is brought to the first station. The magnetic bearing is taken as a check. The upper motion is then unclamped, a sight is taken at the third station, and the azimuth and bearing are found.

By sighting at the first station with the backward bearing of the line laid off, the zero of the circle is placed in the meridian, or, in other words, when the telescope passes through a 0° or 360° reading, it will be on a line parallel to the assumed meridian.

Attention is called to the fact that the magnetic needle is not used at the second station to orient the horizontal circle, but only as a check on the setting of the angle on the vernier. If the telescope were turned at the second station, as at the first, using the magnetic bearing, the traverse would be practically a compass traverse where the bearings were used instead of azimuths.

Problem D2 gives the field work of conducting an azimuth traverse.

Deflection Angle Traverse. In a deflection traverse, the deflection of a line from a previous line is determined. This is found as follows: vernier A is set at zero, the telescope is plunged and the line of sight is brought to the back station by use of the lower motion. The telescope is then brought to its normal position, and the upper motion unclamped, and the line of sight brought to the forward point. The deflection angle to the right or left is found by use of the vernier A. It is to be noted that when the backward sight is being taken, vernier B is under the eye-piece end of the telescope, and when the forward sight is taken, vernier A is under the eye-piece end. If the line of collimation is not in adjustment, the method of deflection angles will not give good results. This may be overcome by keeping the telescope in its normal position at both sights, and by setting vernier A at 180° when taking the backward sight.

Traverse by Interior Angles. The interior angles may be measured in the usual way and the distance obtained either by the tape or the stadia.

ADJUSTMENTS OF THE TRANSIT

The different parts of the transit should be in a certain relation to each other, and it is essential that the instrument be placed in good adjustment if satisfactory results are to be secured.

The elementary lines in the transit are: (1) the axes of the plate levels; (2) the vertical axis of the instrument; (3) the horizontal axis of the telescope; (4) the line of collimation; and (5) the axis of the telescope bubble. The adjustments consist of the following:

I. To make the axes of the plate levels perpendicular to the vertical axis of the instrument. II. To make the line of collimation revolve in a vertical plane when the telescope is turned on its horizontal axis. III. To make the axis of the telescope bubble parallel to the line of collimation. IV. To make the vernier of the vertical circle read zero when the line of collimation is horizontal.

I. To Make the Axes of the Plate Levels Perpendicular to the Vertical Axis of the Instrument. This adjustment is the same in principle as that in the level, of making the axis of the bubble perpendicular to the vertical axis, and is illustrated in Fig. 13. Bring both bubbles to the center, revolve 180°, and correct one-half the error by the leveling screws and the other half by raising or lowering one end of the bubble tube. The screws are turned in a direction previously described. Each bubble should be adjusted separately by placing it parallel to a pair of leveling screws. When this adjustment is made the bubble will remain in the center during a complete revolution, and the axis of revolution will be vertical.

II. To Make the Line of Collimation Revolve in a Vertical Plane when the Telescope is Turned on its Horizontal Axis. This adjustment consists of two parts: (*a*) To make the line of collimation perpendicular to the horizontal axis of the instrument; and (*b*) to make the horizontal axis of the telescope perpendicular to the vertical axis of the instrument.

(*a*) *To make the line of collimation perpendicular to the horizontal axis of the telescope.* When this condition exists, a straight line may be obtained by setting up over one point, sighting at another, plunging the telescope and lining in a point. The method of adjustment is as follows, referring to Fig. 22: Set the instrument up on nearly level ground, at a point O, where a clear sight may be had of a point A, a few hundred feet away, and bring the line of collimation to it. Plunge the telescope, and if the line of collimation is not perpendicular to the horizontal axis of the telescope, it will mark a point B. Revolve the telescope by unclamping the upper motion and sight again on the point A. Plunge the telescope and the line of collimation will now strike the point C. A point D, half-way between B

and C, will be in the straight line AO. To *adjust* the line of collimation, the reticule is moved so that the cross-wires intersect on a point E, the distance CE being one-quarter of the distance CB. It is easily seen by reference to Fig. 22 why the angle COB is four times the true error, the angle FOG.

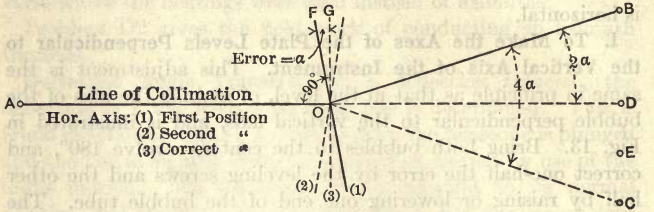


FIG. 22

(*b*) *To make the horizontal axis of the telescope perpendicular to the vertical axis of the instrument.* The adjustment is as follows, referring to Fig. 23: Set the instrument up firmly about twenty

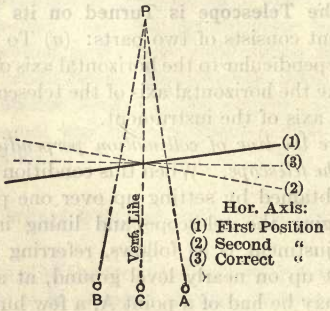


FIG. 23

feet from a building, and level carefully. Select as high a point (represented by P) on the building as possible, and bring the intersection of the cross-wires to it. Swing the telescope down and set a point A near the base of the building. Plunge the

telescope, revolve in azimuth, and again sight at the upper point. Depress the telescope and mark another point B. If the horizontal axis of the telescope is truly horizontal, the points A and B will coincide. If not, adjust for one-half the error by raising or lowering one end of the horizontal axis. Fig. 23 shows why the apparent error AB is twice the real error AC, and needs no particular explanation. It is important that the intersection of the wires be set on the true position, which is half-way between A and B, and that the raising or lowering of the horizontal axis be done while pointing at the *upper* point. In the latter position a movement of the axis is easily seen by the changing position of the wires. If done with the telescope nearly level, no noticeable change is seen, and the correct amount of adjustment is not easily gauged. This adjustment is quite commonly called the adjustment for *height of standards*, and consists in making the horizontal axis of the telescope parallel to the horizontal plane through the axis of one of the plate levels, the axis of the plate level having previously been made perpendicular to the vertical axis of the instrument. This adjustment is sometimes made by comparing with a long plumbline, the weight of which rests in a pail of water.

III. To Make the Axis of the Telescope Bubble Parallel to the Line of Collimation. When this adjustment is made, the instrument may be used as a level. There are two common methods of making this adjustment.

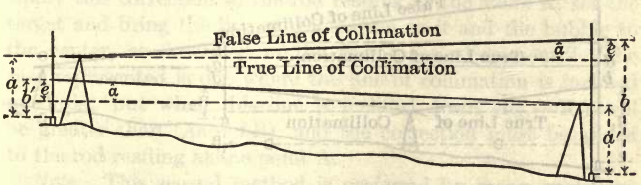


FIG. 24

First Method. Fig. 24. Drive two stakes on nearly level ground, from 200 to 400 feet apart. Set the instrument up near one stake, so that when the rod is placed on it the eye-end of the telescope will swing within an inch of its face. Level

the instrument and sight through the object-glass end of the telescope, and note the rod reading, calling it a. Then take a reading on the other stake, being careful that the bubble is in the center, and call this reading b. Then supposing that the line of collimation is not horizontal when the bubble is in the center, but is out by an angle a which makes an error e in the distance between the stakes. Then the difference in elevation of the two stakes is equal to $a - (b - e)$. Remove the instrument to a similar position near the other stake, repeat the observations, calling the readings a' and b', and the difference in elevation is now $(b' - e) - a'$. If the instrument is in adjustment, e becomes zero, and $(a - b)$ should equal $(b' - a')$; but if it does not, equate the two values for the difference in elevation of the two stakes, and solving for e, we get $e = \frac{1}{2}\{(b' - a') - (a - b)\}$. Apply this with its correct sign to the last rod reading, bring the line of collimation to the center of the target by the use of the tangent screw on telescope, and then bring the bubble to the center of the tube by the use of the altitude screws as previously described. Repeat the observation until the work checks sufficiently well. In the figure given the line of collimation was inclined upwards.

Note. The level vial might have been left in the same position, and the correction made by changing the line of collimation by shifting the reticule.

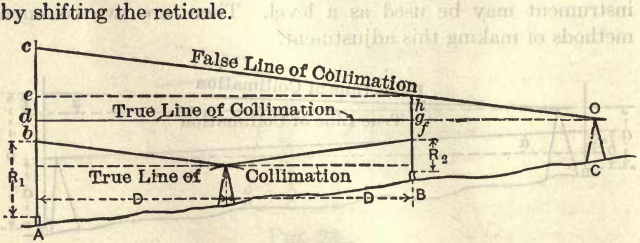


FIG. 25

Second Method. Fig. 25. Drive two stakes, A and B, at a distance of 300 to 400 feet apart, and on slightly rising ground. Set the instrument up *exactly* half-way between them. Take rod readings on the two stakes, making sure that the bubble

is exactly in the center at each sight. If these readings are designated by R_1 and R_2, then $(R_1 - R_2)$ will be the *true* difference in elevation of the stakes (unless the instrument is otherwise very badly out of adjustment), since the two stakes are equidistant from the instrument, and the bubble is in the center for each sight. Then take the instrument to a point C back of B and in line with A and B, making the distance BC some exact fraction of AB, say 50 ft. if the distance AB is 250 ft. With two leveling screws in the direction of the line AC, and the bubble in the center, take rod readings on B and A, which may be represented by B*h* and Ac. The line O*d* will represent a horizontal line through the point O, and the correct position of the line of collimation, and *cd* will be the error in the distance CA. Draw the horizontal line *he* through *h*, and then *ce* is the error in the distance AB, which we know, since $(R_1 - R_2)$ is the true difference in elevation of the stakes, which, if the instrument is in adjustment, should be the same, no matter where the instrument is set up. $(Ac - Bh) - (R_1 - R_2)$ = the error in the distance AB, or *ce* in this case. As the instrument is now set up at O, what is wanted is the error *cd* in the distance AC. This is obtained from the similar triangles *hec* and O*dc*, by the proportion

$$cd : ce :: Od : he\ (= BA), \quad \text{or} \quad cd = \frac{ce \times Od}{he}.$$

Apply this correction to the rod reading at the stake A, set the target and bring the line of collimation to it and the bubble to the center, as described in the first "peg-adjustment." The case represented is one where the line of collimation is inclined upwards; but when this line is inclined down $(R_1 - R_2)$ will be greater than $(Ac - hB)$, and the correction must be added to the rod reading at the point A.

Note. This second method is preferred by many engineers, as it is considered difficult to get the height of the cross-wires in the first method by sighting through the object-glass end of the telescope. This defect may be overcome by placing the instrument *back of each stake* at a distance of about eight feet (shortest distance for which the telescope can be focussed) and then taking the rod readings in the usual manner.

The first method has the advantage of requiring no measurement of distances. In the second, several readings should be taken on each stake, and the mean taken to counteract errors of setting the target. If permanent and unyielding monuments are set at the points A and B, and their difference of elevation accurately obtained, then to make the adjustment only the one set up at the point C is necessary.

IV. To Make the Vernier of the Vertical Circle read Zero when the Line of Collimation is Horizontal. Having made the axis of the telescope-bubble parallel to the line of collimation, bring the bubble to the center, and if the vernier of the vertical circle is adjustable, bring it so that its zero coincides with that on the limb. If the vernier is not adjustable, note the *amount* and *sign* of the angular error, which is called the " index-error," and apply it to all vertical angles.

PROBLEM D1. MEASUREMENT OF THE ANGLES OF A QUADRILATERAL

Equipment. Transit, two range poles, hatchet, stakes and tacks.

Problem. *To measure the angles of a quadrilateral.*

Method. Drive four stakes forming a quadrilateral with sides approximately equal, and between 200 and 400 feet in length. Set up over each stake in turn, measuring each interior angle of the figure from two to six times as assigned by the instructor. The method of making an observation at a station is as follows:

Set vernier A at zero (or near zero) and read vernier B. With the upper motion clamped, sight over the telescope at the left-hand point. Clamp lower motion, then look through the telescope and bring the line of collimation to the tack in the stake by use of the *lower slow motion*, or *tangent screw*. Unclamp upper motion, turn the telescope, and bring the line of collimation to the tack in the second stake. Read both verniers and record them. Unclamp the lower motion and again sight at the first stake, using the lower clamp and tangent screw. Again unclamp the upper motion and proceed as before, finally reading both verniers.

Proceed in a similar way for as many measurements as may be desired. The observations at the other stations are conducted in like manner.

Computations. Find the mean of the vernier readings on each horizontal line, taking the mean of the minutes only, with the degrees on vernier A. Then the differences between the successive mean readings will give several values of the angles. These values should not differ by more than one minute of arc. Find the mean of these differences, which gives the probable value of the angle. Sum the angles and state the error.

Remark. This problem may be modified to suit the skill of the observer, either by increasing the number of the measurements, or by increasing the number of sides in the figure.

Method of Repetition. In precise surveying, the " method of repetition " is used, in order to eliminate the errors of adjustment and of observation. The essentials of this method are: first, measuring the angles from left to right with telescope direct, and then from right to left with telescope inverted; second, the verniers are not read until after the last repetition of the angle. The value of the angle is then found by subtracting the mean of the vernier readings on the first sight from the mean vernier readings on the last repetition, and dividing by the number of repetitions. Sometimes the readings at the end of the first repetition are made to give an approximate value of the angle, in order to tell the number of repetitions that should be made. The repetitions should not be more than eight in number, and it is considered best, on account of the errors in graduation, not to pass around the circle the second time.

PROB. DI. MEASUREMENT OF ANGLES OF A QUADRILATERAL

Line	Ver. A	Ver. B.	Mean	Diff.	Angle
AB	0°22′	— 23′	0°22′30″		
AD	69°12′	— 12′	69°12′	68°49′30″	
AB(2)	69°12′	— 12′	69°12′		
AD(2)	138°01′	— 00′	138°00′30″	68°48′30″	
AB(3)	138°01′	— 00′	138°00′30″		
AD(3)	206°50′	— 50′	206°50′	68°49′30″	68°49′10″
BA	2°12′	— 12′	2°12′		
BC	99°28′	— 28′	99°28′	97°16′	
BC(2)	196°44′	— 44′	196°44′	97°16′	
BC(3)	294°01′	— 01′	294°01′	97°17′	97°16′20″
CB	1°11′	— 11′	1°11′		
CD	93°58′	— 58′	93°58′	92°47′	
CD(2)	186°45′	— 45′	186°45′	92°47′	
CD(3)	279°32′	— 32′	279°32′	92°47′	92°47′00″
DC	2°43′	— 43′	2°43′		
DA	103°51′	— 51′	103°51′	101°08′	
DA(2)	204°59′	— 59′	204°59′	101°08′	
DA(3)	306°07′	— 07′	306°07′	101°08′	101°08′00″
DA	Bearing S 79°30′ E			Sum —	360°00′30″
				Error —	30″

PROBLEM D2. TRAVERSING WITH THE TRANSIT

Equipment. Transit, two range poles, 100-ft. steel tape, set of marking pins, hatchet, stakes, and tacks.

Problem. *To traverse a closed area or a field.*

Method. The solution here given will be by the use of azimuth. For other methods, see pages 68 to 70.

Drive six stakes, forming a hexagon with sides at least 250 ft. in length. Set the transit up over one station, and with vernier A at zero, place the line of sight on the magnetic south. Clamp the lower motion. Loosen the upper plate and sight on station 2, reading the azimuth on vernier A and taking a needle reading; also sight at station 6, obtaining the azimuth of the line 1–6 and its bearing. Then set up at station 2. Lay off the backward azimuth of the line 1–2 by use of vernier A, sight at station 1, and clamp the lower motion. Unclamp the upper motion and read the azimuth of the line 2–3 and note its bearing. Proceed in a similar manner at stations 3, 4, 5 and 6. Measure the sides of the figure.

The *backward azimuth* of a line is equal to the *forward azimuth* $\pm$ 180°. The set of numbers on the transit should be used which increases from 0° to 360° in a clockwise direction, and care should be taken in laying off the backward azimuth that when the telescope is turned clockwise the plate reading will increase. See Fig. 21 for illustration of forward and backward azimuth.

Modification. The above problem may be modified by using the corners of a field whose sides can be measured directly.

Remark. Instead of using azimuths, interior angles or deflection angles may be used.

Computations and Form of Notes. From the measured azimuths, calculate the bearings. Find the latitudes and departures of the different courses, and the error of closure. For definition of these terms and for the methods of computation, see pages 143 to 146.

PROB. D2. TRAVERSING

Inst. at	Sight at	Azimuth	Distance	Mag. Bearing	Calc. Bearing
1	South	0°00′		S	
	2	169°23′	114.78	N10°40′W	N10°37′W
	6	273°07′	130.13	S87°00′E	S86°53′E
2	1	349°23′		S10°45′E	S10°37′E
	3	206°02′	78.85	N25°30′E	N26°02′E
3	2	26°02′		S25°50′W	S26°02′W
	4	252°20′	105.83	N72°15′E	N72°20′E
And so on			Azimuth	Error =	0°02′

WITH THE TRANSIT.

Party, date, equipment, etc. as usual

Sides	Latitude		Departure	
	+	−	+	−
1-2	112.82			21.15
2-3	70.85		34.60	
And so on				

Error of closure = $\frac{\sqrt{\text{Error Lat.}^2 + \text{Error Dept.}^2}}{\text{Perimeter}}$

PROBLEM D3. SURVEY OF A CITY BLOCK

Equipment. Transit (reading to 20″ if possible), two range poles, steel tape, set of marking pins, plumb-bobs, hatchet, stakes, nails, and tacks.

Method. Monuments in many cities are located outside of the street corners. They are often in line in one direction, and a certain number of feet from the other line. In the figure, the monument at D″ is on the line AD prolonged and is two feet in a perpendicular direction from the line DC. It is necessary to set monuments in this way because fence posts or buildings may be at the corners, or buildings and improvements may extend to the corners.

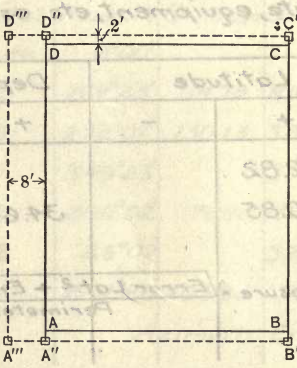


FIG. 26

Two cases may arise in the survey of a city block. First, when the lengths and directions of the property lines may be obtained by direct measurement, and second, when the lengths and directions must be obtained by use of offset lines.

In the first case, set up the transit over one corner monument. Measure the angle between adjacent monuments. The angle should at least be doubled, and may be measured by the method described in Problem D1. The distances between monuments should be measured at least twice. The angles at the other

stations may be obtained in a way similar to that at the first. The magnetic bearing of one line in the figure may be taken as a reference line. Sum the measured angles, and if the error is within limits, compute the bearings of the sides, and find the area as described under " computations " below.

In the second case, suppose ABCD is a city block with the monuments A″, B″, C″, D″ on line in one direction, and two feet in the street in the other direction. The length of the property line AB may be found by measuring the distance between the monuments A″ and B″, and similarly for the line DC. The length of the line AD, which cannot be directly measured, may be found by first setting a stake at A‴, 8 ft. from A″, and at about right angles to the line AD; also a similar stake at D‴. Then set up at A‴, sight at D‴, turn 90° and, if the line of collimation does not strike the point A″, shift the center of the transit along the line of A‴D‴ until it coincides. Proceed similarly at D‴, and then measure the length of the line between the two transit stations. This line is equal to the line A″D″, and the length of AD may be found by subtracting the sum of AA″ and DD″. To obtain the interior angle A, a string intersection of the lines A‴D‴ and A″B″ is found. Set up at this intersection, and measure the interior angle which is equal to the angle A. Angles at the other corners may be found in a similar manner.

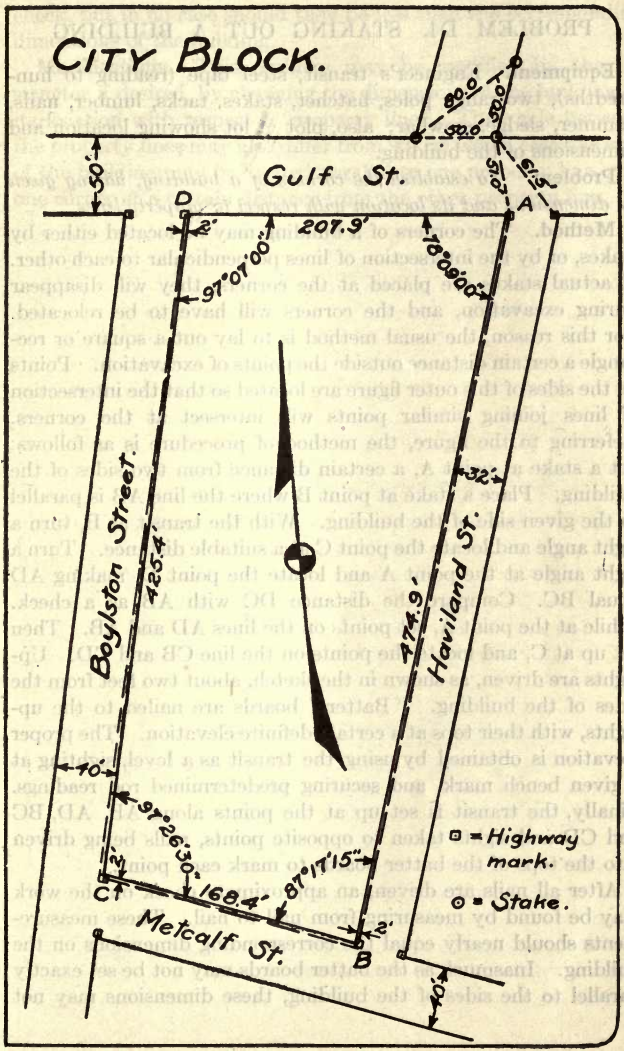
Remark. The method above given is general, and the student should be able to solve any problem that may arise.

Computations and Plotting. A description of the methods of computing the area of a block is given in Problem J2, and the work of plotting, in Problem K3.

Notes. Notes may best be a combination of tabular form and sketch. The accompanying two-page illustration may be followed as a guide. Usually, in the larger surveys, the notes extend from the bottom of the page upward, but in this problem it seems unnecessary. In a convenient place on the right-hand page, the party, date, and equipment may be given.

PROB. D3. SURVEY OF A

Line	Ver. Read.	Angle.	Dist.	Mag. Bear.	Calc. Bear.
AD	0°00'00"				
AB	78°09'00"		474.9	S 16°50' W	S17°01'00"W
AB (2)	156°18'00"	78°09'00"			
BA	0°00'00"				
BC	87°17'00"		168.4	N 70°45' W	N70°16'15"W
BC (2)	174°34'30"	87°17'15"			
CB	0°00'00"				
CD	97°26'30"		425.4	N 12°17' E	N12°17'00"E
CD (2)	194°53'00"	97°26'30"			
DC	0°00'00"				
DA	97°07'00"		207.9	S 85°00' E	S84°30'00"E
DA (2)	194°14'00"	97°07'00"			
Sum of ∠s =		359°59'45"			
Error =		15"			


CITY BLOCK.
80.0'
80.0'
50.6'
50'
Gulf St.
51.5'
50.2'
D
A
2'
207.9'
97°01'00"
78°00'00"
Boylston Street.
425.4'
32'
474.9'
Haviland St.
40'
91°26'30"
87°17'15"
2'
2'
168.4'
Metcalf St.
B
40'
□ = Highway mark.
⊙ = Stake.

PROBLEM D4. STAKING OUT A BUILDING

Equipment. Engineer's transit, steel tape (reading to hundredths), two range poles, hatchet, stakes, tacks, lumber, nails, hammer, sledge, crowbar; also, plot of lot showing location and dimensions of the building.

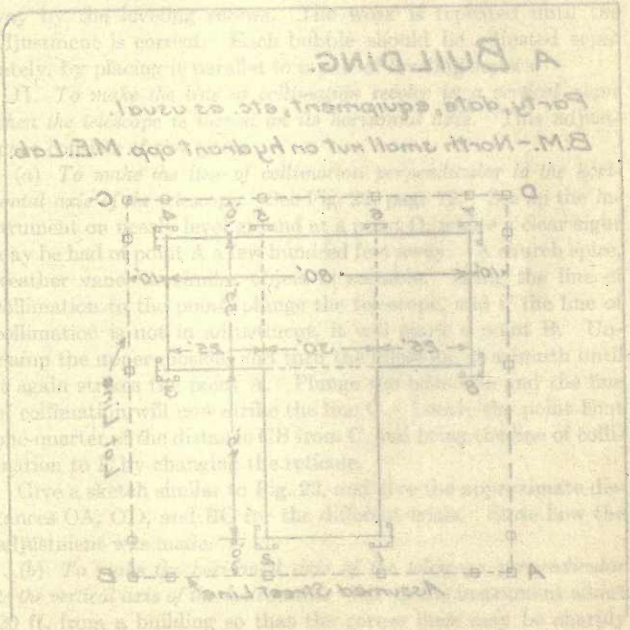
Problem. *To establish the corners of a building, having given its dimensions and its location with respect to property lines.*

Method. The corners of a building may be located either by stakes, or by the intersection of lines perpendicular to each other. If actual stakes are placed at the corners, they will disappear during excavation, and the corners will have to be relocated. For this reason, the usual method is to lay out a square or rectangle a certain distance outside the points of excavation. Points on the sides of this outer figure are located so that the intersection of lines joining similar points will intersect at the corners. Referring to the figure, the method of procedure is as follows: Set a stake at point A, a certain distance from two sides of the building. Place a stake at point B where the line AB is parallel to the given side of the building. With the transit at B, turn a right angle and locate the point C at a suitable distance. Turn a right angle at the point A and locate the point D, making AD equal BC. Compare the distance DC with AB as a check. While at the point A, set points on the lines AD and AB. Then set up at C, and locate the points on the line CB and CD. Uprights are driven, as shown in the sketch, about two feet from the sides of the building. "Batter" boards are nailed to the uprights, with their tops at a certain definite elevation. The proper elevation is obtained by using the transit as a level, sighting at a given bench mark, and securing predetermined rod readings. Finally, the transit is set up at the points along AB, AD, BC and CD and sights taken to opposite points, nails being driven into the tops of the batter boards to mark each point.

After all nails are driven, an approximate check on the work may be found by measuring from nail to nail. These measurements should nearly equal the corresponding dimensions on the building. Inasmuch as the batter boards may not be set exactly parallel to the sides of the building, these dimensions may not

check, but in no case should they be less than the corresponding dimensions of the building.

Modifications. This problem may be modified by the instructor if desired, by changing the dimensions of the building or its location with respect to property lines. The angle between the property lines may also differ from 90°, in which case one side of the building may be located parallel to one property line, and one corner at a certain distance from the other property line.



PROB. D4. STAKING OUT

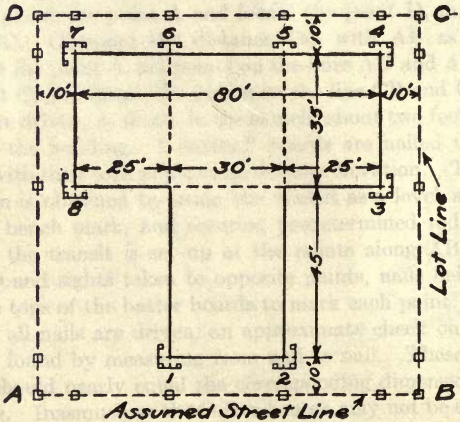
+S	H.I.	-S	Elev.	Sta.
1.94	559.03		557.09	B.M.
		2.03	557.00	All Corners.

Give a brief description of the method used in locating the stakes and batter boards.

A BUILDING.

Party, date, equipment, etc. as usual.

B.M. – North small nut on hydrant opp. M.E. Lab.



PROBLEM D5. ADJUSTMENT OF THE ENGINEER'S TRANSIT

Equipment. Engineer's transit, steel tape, level rod, hatchet, stakes, and adjusting pins.

Theory. See pages 70 to 76.

Method of Making Adjustments with Form of Notes. Use both pages of the field book, giving data with regard to party, equipment, etc., in the upper part of the right-hand page.

I. *To make the axes of the plate levels perpendicular to the vertical axis of the instrument.* Bring both bubbles to the center, revolve 180°, and correct one-half the error in each bubble by raising or lowering one end of the tube, using the capstan screw at the end of the vial. The bubble is brought back the remainder of the way by the leveling screws. The work is repeated until the adjustment is correct. Each bubble should be adjusted separately, by placing it parallel to a pair of leveling screws.

II. *To make the line of collimation revolve in a vertical plane when the telescope is turned on its horizontal axis.* This adjustment consists of two parts.

(*a*) *To make the line of collimation perpendicular to the horizontal axis of the telescope.* See Fig. 22, page 72. Set up the instrument on nearly level ground at a point O, where a clear sight may be had of point A a few hundred feet away. A church spire, weather vane, or similar object is suitable. Bring the line of collimation to the point, plunge the telescope, and if the line of collimation is not in adjustment, it will mark a point B. Unclamp the upper motion, and turn the telescope in azimuth until it again strikes the point A. Plunge the telescope and the line of collimation will now strike the line C. Locate the point E at one-quarter of the distance CB from C, and bring the line of collimation to E by changing the reticule.

Give a sketch similar to Fig. 22, and give the approximate distances OA, OD, and BC for the different trials. State how the adjustment was made.

(*b*) *To make the horizontal axis of the telescope perpendicular to the vertical axis of the instrument.* Set up the instrument about 20 ft. from a building so that the corner lines may be sharply

defined. Level carefully. Select as high a point as possible on the building, and bring the intersection of the cross-wires to it. Depress the telescope, and set a point near the base of the building. Plunge the telescope, turn in azimuth, and again sight at the upper point. Depress the telescope and mark a second point B. Correct one-half the error by raising or lowering one end of the horizontal axis. It is to be noted, that the *actual adjustment is made while sighting at the higher point.* Therefore, one-half the distance is laid off at the base of the building, the line of collimation brought to it by a tangent screw, and the adjustment made after the telescope has been raised to the higher point.

In the field book give a sketch similar to Fig. 23, page 72, with the approximate height of P above the lower point, and the approximate distance from the transit to the building. Give the errors in the different trials, and state how the adjustment was made.

III. *To make the axis of the telescope bubble parallel to the line of collimation.* Use either the first or second "peg test" as on pages 73 to 76.

In the field book give a sketch similar to Figs. 24 or 25, with all rod readings and distances. Give the corrected rod reading for making the adjustment. Outline the method of adjustment, with check on the work.

IV. *To make the vernier of the vertical circle read zero when the line of collimation is horizontal.* Bring the telescope bubble to the center, and note the reading of the vertical circle. If it is not zero, move the zero on the vernier so that it will coincide with that on the limb. If the vernier is not adjustable, note the amount and sign of the angular error, which is the "index" error.

CHAPTER VI

TOPOGRAPHICAL SURVEYING

A *topographical survey* is one which gives both the position of points and the character of the surface of the ground, with respect to relative heights; also the kind of vegetation. There are three methods of making such a survey.

First, by dividing the area into squares or rectangles, by use of the transit and tape, and obtaining the elevations of all corners by use of the level. This method is used over small areas where accurate results are desired. Problem E3 describes this method.

Second, by use of the plane table. Where the survey is made with a plane table, stadia rods may be used and the work is then similar to that in the third method, except in the fact that the reductions and maps are made in the field. For a complete description of the plane table, see pages 101 to 105.

Third, with an engineer's transit and stadia rods. This method is used for large areas where extreme accuracy is not required. It is the most rapid method of all. In this method a point is located both horizontally and vertically. A point is located horizontally by obtaining its direction from the meridian passing through the transit station, and its distance from the station by a reading on the stadia rod held at the point. The difference in elevation between the point and the transit station is found by reading the vertical angle when the telescope is sighted at the point. The line of collimation should be as far from the ground at the point sighted at as the horizontal axis is above the instrument stake. A right triangle may be solved, and the difference in elevation found. For description of this method see Problem M3.

THE STADIA

Stadia Wires. In a transit used for stadia work there are two additional horizontal hairs called stadia hairs. These hairs are placed equidistant from the horizontal hair. Ordinarily they are

placed on the same reticule as the regular cross-hairs, in which case they are called fixed-hairs. They are sometimes free from the main reticule and are adjustable. The fixed hairs are considered the better.

Principle of the Stadia. From a certain point in front of the object glass, the space intercepted on a rod varies proportionally with the distance from this point to the rod. The position of this point depends upon the particular telescope. The problems in stadia work are: first, to find, when the telescope is horizontal, the constant which should be multiplied by the space intercept of the stadia hairs, to give the distance from the point in front of the

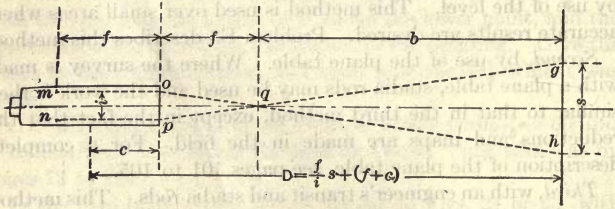


FIG. 27

objective to the rod; second, to find the horizontal distance when the telescope is inclined; third, to find the difference in elevation of points.

First, to find the stadia constant. In Fig. 27, the points m and n represent the position of the stadia hairs. Rays of light pass from the points g and h through q to the object glass, and finally parallel to the axis of the telescope through the points m and n.

From the similar triangles formed, $s : b :: i : f$, from which

$$b = \frac{f}{i}s,$$

and

D = the distance from the center of the instrument to the rod

$$= \frac{f}{i}s + (f + c) = ks + (f + c).$$

The determination of $\frac{f}{i}$ or k is explained in Problem E1. Briefly this work consists in laying off a distance $(f + c)$ from the center of the instrument and setting a point, and from this point laying off a base line, noting the space intercept on the rod and the distance of the rod from this point q. The stadia constant is taken as the average of each distance divided by its space intercept. It is to be noted that the work should be done on a nearly level stretch of ground, and that the telescope bubble should be practically in the center at all sights; that is, the upper or lower cross-wire should not be moved over more than the smallest graduation of the rod.

The value of f, which is the focal length of the lens, is found by sighting on a point an infinite distance away, and measuring the distance from the plane of the cross-hairs, to the center of the

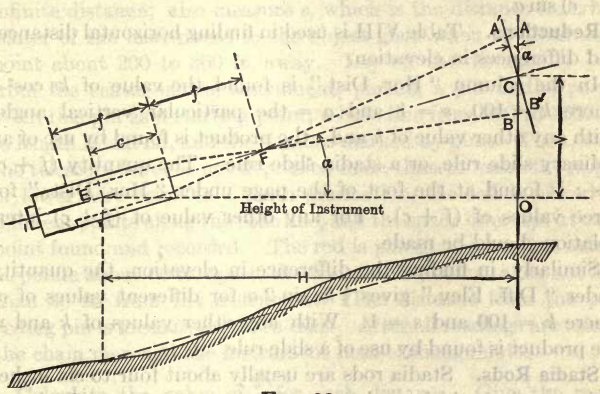


FIG. 28

object glass. The distance c is found by sighting at a point about 200 ft. away, and measuring the distance from the center of the instrument to the center of the object glass.

Second, to find the horizontal distance when the telescope is inclined. If the rod were held perpendicular to the line of sight, a portion of it would be in the position A′B′ in Fig. 28. It is not

practical to do this, as there is no easy method of securing the proper angle of inclination; therefore, the rod is held vertical, and the correction is made to bring it to the position A′B′. The inclined distance EC may be obtained, and finally the horizontal distance EO.

Let $A'B' = s'$ and $AB = s$.

Then $A'B' = AB \cos a = s \cos a$.

In the first case, the distance

$$EC = ks' + (f + c) = ks \cos a + (f + c).$$

But $EO = H = EC \cos a$, and substituting the value of EC from the above equation we get $H = ks \cos^2 a + (f + c) \cos a$.

Third, to find the difference in elevation of points. $CO = V = EC \sin a = ks \sin a \cos a + (f + c) \sin a = \frac{1}{2} ks \sin 2a + (f + c) \sin a$.

Reductions. Table VIII is used in finding horizontal distances and differences in elevation.

In the column "Hor. Dist." is found the value of $ks \cos^2 a$ where $k = 100$, $s = 1$ and $a =$ the particular vertical angle. With any other value of k and s the product is found by use of an ordinary slide rule, or a stadia slide rule. The quantity $(f + c) \cos a$ is found at the foot of the page under "Hor. Dist.," for three values of $(f + c)$. For any other value of $(f + c)$ interpolation should be made.

Similarly, in finding the difference in elevation, the quantity under "Diff. Elev." gives $\frac{1}{2} ks \sin 2a$ for different values of a, where $k = 100$ and $s = 1$. With any other values of k and s, the product is found by use of a slide rule.

Stadia Rods. Stadia rods are usually about four to six inches wide, one inch thick, and ten to fourteen feet long. Rods are sometimes strengthened by cleats on the back, with or without oblong holes for use as handles. The top and bottom of the rod should be protected by metal shoes.

The symbols on a rod are usually in black, on a white background. The test for a good rod will come in sighting from the open into a dark area such as in heavy brush, or in forest work.

PROBLEM E1. DETERMINATION OF STADIA CONSTANTS

Equipment. Engineer's transit, two stadia rods, steel tape, set of marking pins, stakes, hatchet, and engineer's scale.

Problem. *To determine the constants f, c, and* $\frac{f}{i}$ *for a given instrument.*

Theory. From a point $(f + c)$ from the center of the instrument, the space intercepted on a rod by the stadia wires varies directly with the distance from this point.

Method. Select a practically level stretch of ground and set up the transit over a stake or pin. By use of an engineer's scale measure f, which is the distance from the cross-wires to the center of the object glass, when it is focussed on an object at an infinite distance; also measure c, which is the distance from the center of the instrument to the object glass when focussed on a point about 200 to 300 ft. away. Lay off the distance $(f + c)$ from the center of the instrument, placing a pin at the point. With this pin as a starting point, a base line from 400 to 1000 ft. in length is laid off, and the stations marked by pins. Then, with the telescope level or not depressed more than to make the upper or lower wire come to a tenth graduation, the rod is placed at different points along the base line, and the space intercept at each point found and recorded. The rod is placed at even foot marks at points about 60 ft. apart, the first reading being taken not less than 50 ft. from the instrument. The distance from the preceding pin is measured in each case. After all readings are taken, the chain men and the instrument man exchange notes.

Calculate the value of $\frac{f}{i}$ for each distance. Give the mean value of $\frac{f}{i}$.

PROB. E I. DETERMINATION

Number	Dist.	Wire Intercept	$\frac{f}{i} = \frac{k}{s}$.	
1	60	.6	100.0	
2	110	1.1	100.0	
3	170	1.7	100.0	
4	220	2.2	100.0	
5	280	2.8	100.0	
6	330	3.3	100.0	
7	390	3.9	100.0	Mean Value
8	440	4.4	100.0	= 100.00

OF STADIA CONSTANTS.

June 3, 1912.

L.J. Atkinson, Transitman.

G.S. Carson, Head Chainman.

F. B. Crawford, Rear Chainman.

A. B. Hendel, Note keeper.

Equipment – Transit No. 4, Rods Nos. 9 & 10, Tape No. 24, Hatchet No. 4, Strop No. 8.

$f = 7\frac{13}{16}''$. $c = 5\frac{5}{16}''$.

$f + c = 13\frac{1}{8}'' = 1.09$

PROBLEM E2. TRAVERSING WITH THE STADIA

Equipment. Engineer's transit, two stadia rods, hatchet, stakes and tacks.

Problem. *To traverse either a closed area or a field with the transit and stadia.*

Method. The method of procedure is the same as that given in Problem D2, except that the distances are obtained by the stadia, instead of by tape or chain.

At the first station, place the line of sight on magnetic south, as in Problem D2. Unclamp the upper motion, and turn to station 2, reading the azimuth, bearing, rod reading, and vertical angle. Take the same information on the last station. In obtaining the rod reading, the upper or lower wire is placed on an even foot mark on the rod, and the space between the two wires is noted. Attention is called to the fact that the wire may be moved over some vertical distance, regardless of the position of the bubble.

In finding the vertical angle, however, the height of the cross-wires above the ground is found, and the *middle* wire is sighted at this height when sighting at the adjacent stations.

The method of procedure at the second station is as follows: Lay off the backward azimuth on the plate, and sight at the first station, using the lower motion. The rod reading, vertical angle and bearing are taken; the upper motion is then unclamped and the information on the forward station is obtained.

The backward and forward rod readings should check within 0.02 of a foot at the most, and the vertical angles should check within two minutes. If either or both do not check within this limit, investigate as follows: See that the transit is level; that the height of the cross-wires was measured correctly; that a sight was taken at a proper height on the rod; and finally, re-measure the rod readings and the vertical angle. If these measurements agree with those first taken at this station, an asterisk or check mark should be placed near them in the notes, and the forward readings should be rejected in computation.

It is here assumed that there is no index error on the vertical circle. If there be an index error, the backward and forward

angles *should not check*, and the mean of the two would give the correct value of the vertical angle.

Modification. As in Problem D2 the number of sides in the figure may be changed.

Computations. Reduce the measurements to the horizontal and find the differences of elevation of the various stations by the formulas for inclined sights as given on pages 93 and 94. Use the mean readings of the vertical angles and rod readings in the formulas. Carry the horizontal distances to the nearest tenth of a foot, and the differences in elevation to the nearest hundredth of a foot. Sum the elevations, and state the error in elevation. On the right-hand page state the error in azimuth. If desired, the error of closure may be found as in Problem D2.

PROB. E2 AZIMUTH TRAVERSE

Inst. at	Sight at	Azimuth	Obs. Dist.	Vert. Ang.	Mag. Bear.
1	South	0°00′			S
	2	32°20′	134.	+0°26′	S32°15′W
	6	106°31′	200.	−0°28′	N73°30′W
2	1	212°20′	134.	−0°25′	N32°30′E
	3	111°05′	142.	+0°15′	N68°50′W

And so on. Error in Azimuth = 0°01′

BY TRANSIT AND STADIA.

Party, date, equipment, etc. as usual.

Sides	Horizontal Dist.	Diff. of Elev.
1–2	135.0	+1.00
2–3	143.0	+0.60

And so on.

Error in diff. of elevation = +0.1′.

Error in azimuth = 0°01′.

PROBLEM E3. TOPOGRAPHICAL SURVEY OF A SMALL AREA BY TRANSIT, LEVEL, AND TAPE

Equipment. Transit, level (unless transit has telescope bubble), self-reading rod, steel tape, set of marking pins, hatchet and stakes.

Theory. The most accurate method of making a topographical survey is to divide the given area into squares or rectangles, and find the elevations of the corners of these figures above a given or an assumed datum plane. This is a convenient method for making the survey of the sight for a dam or a reservoir, a viaduct or a borrow pit. Elevations of the corners may be taken before and after the construction is completed, and the amount of earthwork computed. See Problem J3 for method of computation, and Problem K3 for directions on plotting such a survey.

Survey and Form of Notes. Divide the area into squares or rectangles, starting with any convenient base line. (One boundary line of the area may be taken.) Find the elevations of the corners above an assumed datum plane.

The level notes may be kept in the regular profile leveling form. (See Problem B2.) A sketch is given on the right-hand page showing the arrangement of the squares or rectangles. For convenience the stations along the base line may be called A, B, C, D, etc., and those along the perpendiculars 0, 1, 2, 3, etc. Any point is given by its coördinates as B2, C3, etc.

The degree of accuracy of the work will depend upon: First, the size of the squares, and the care with which they are laid out; second, the accuracy of the leveling work. If the area is small the ground may be covered from one set-up. Where the given bench mark is at some given distance from the area, or where the ground slope is steep, a return line of levels should be made to the original bench mark, in order to give confidence in the work.

CHAPTER VII

THE PLANE TABLE AND THE SEXTANT

THE PLANE TABLE

The plane table consists of a drawing board, a tripod with a suitable leveling device, and an alidade. The alidade contains a telescope attached to a ruler. In addition there is a plumbing arm for finding a point on the paper immediately over a point on the ground; and there may be a separate box carrying two level

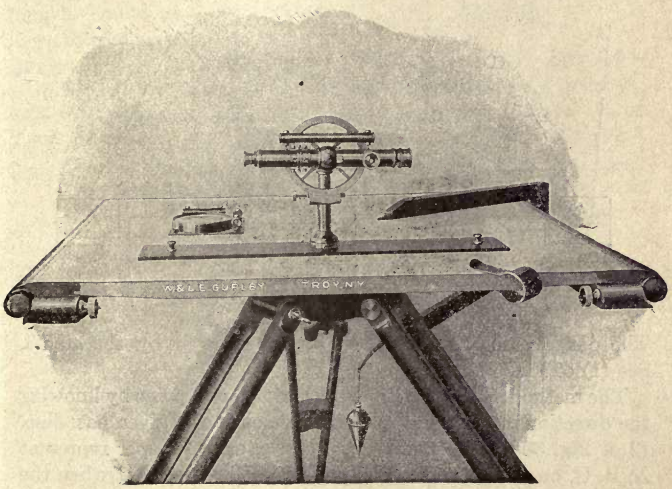


Fig. 29. The Plane Table

vials and a magnetic needle. In some forms a circular level vial and a narrow rectangular compass box are attached to the top of the rule.

The table may be leveled by a ball and socket arrangement, or it may have a set of leveling screws similar to those in the transit. The former is the more common, due to the light weight.

Principle of the Plane Table. With the plane table, angles and distances are plotted directly in the field. Few, if any, notes are taken.

Use of the Plane Table. The plane table is used principally for filling in the details of a survey. A survey by a plane table is generally made by use of one of three methods: radiation, intersection, or traversing. In addition to these methods, two special problems may arise, namely; the *three-point* and the *two-point* problems.

The method of *radiation* consists in locating a point by a distance from a given station, and by a direction from a given line.

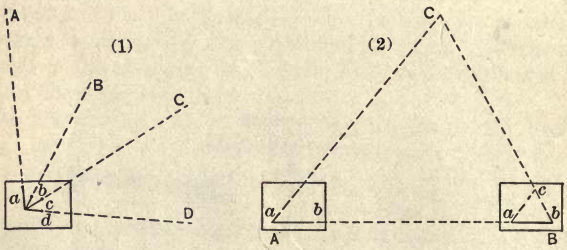


FIG. 30

The distance may be obtained by the tape or by the stadia. See (1) of Fig. 30.

The method of *intersection* is the location of a point by knowing the direction of the point from the two ends of a given base-line. (2 of Fig. 30.) The points *a*, *b*, and *c*, on the paper represent A, B, C, on the ground. The table is oriented so that when the line *ab* coincides with AB on the ground, the point *a* will be over A. A sight is then taken, and a line drawn in the direction of C. The table is then taken to B, and after laying down the line *ab* to the given scale, the table is placed so that *ba* on the paper will coincide with BA on the ground, with *b* on the paper exactly over

B. A sight is then taken on C, and a line drawn toward it. The intersection of this line with the line drawn from point A will give *c*, which corresponds with C on the ground. Many points may be sighted at each station.

The method of *traversing* is similar to that pursued in traversing with a transit, except that the courses are plotted directly. Fig. 31 represents this method. No particular explanation is needed.

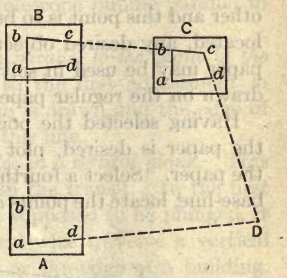


FIG. 31

The Three-point Problem. If three stations are plotted on paper, the position of any station (within the limits of the drawing board) may be found as follows: Place a piece of tracing paper on the table; assume any convenient point on this paper, and draw lines from the point towards the three stations already located. Shift the tracing paper until the three lines traverse their plotted points. The position of the intersection of the three lines then determines the position of the instrument with respect

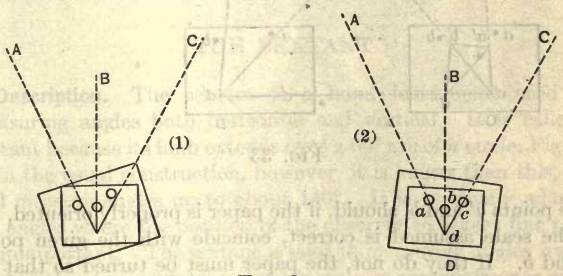


FIG. 32

to the three given points. Fig. 32 illustrates this method, (1) showing the tracing paper, and (2) the final position of the paper on the table.

There are many different solutions for the three-point problem.

The one given above is the usual solution. For discussions of other solutions see more extended works on surveying.

The Two-point Problem. Only two points on the paper are given in this problem. The plane table is to be set up at any other and this point is to be located on the paper, and after being located, any desired objects may be found. A piece of tracing paper may be used in solving the problem, or the lines may be drawn on the regular paper and treated as construction lines.

Having selected the point on the ground, whose location on the paper is desired, plot its position as nearly as possible on the paper. Select a fourth point, and with these two points as a base-line, locate the points a' and b' by the method of intersection.

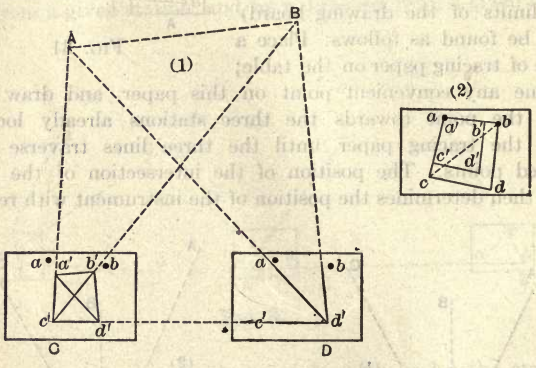


FIG. 33

The points a' and b' should, if the paper is properly oriented, and if the scale assumed is correct, coincide with the given points a and b. If they do not, the paper must be turned so that the line $a'b'$ coincides with ab, with a' coinciding with a. The point b' must be brought to the point b, and a new figure ($abdc$) constructed so that it is similar to $a'b'd'c'$. The point c on the paper will then give the proper location of C with respect to A and B. Fig. 33 illustrates this method, (1) being the first position, and (2) its final position.

Adjustments. The adjustments of the plane table are: (1) to make the axes of the plate levels parallel to the plane of the board; (2) to make the line of collimation describe a vertical plane; (3) to make the axis of the telescope bubble parallel to the line of collimation.

To make the axes of the plate levels parallel to the plane of the board. This adjustment is similar to the first adjustment in the transit, except that a straight line is drawn and the edge of the alidade is turned end for end on this line.

To make the line of collimation revolve in a vertical plane. This adjustment consists of two parts as in the transit. In the first part, however, as the telescope is not supposed to be plunged, it is only necessary to make the vertical wire traverse a vertical line, such as a long plumb-bob cord or the edge of a building. The correction is made by turning the reticule laterally. The second part of the adjustment is made exactly as in the transit.

To make the axis of the telescope bubble parallel to the line of collimation. Either "peg test" may be used, as described on pages 73 to 76.

An outline of the field work of adjusting the plane table is given in Problem F2.

THE SEXTANT

Description. The sextant is a hand instrument used for measuring angles both horizontal and vertical. It is called a sextant because its limb extends over a 60° arc of a circle, Fig. 34. In the usual construction, however, it is longer than this, and will measure angles up to about 140°. It is especially adapted for angles where the position of the observer to a very fine point is unimportant. The sextant is used in measuring angles from a boat, in locating soundings, buoys, etc.; in reconnaissance work, explorations, and for astronomical observations on land or sea.

There are two mirrors (Fig. 35), I called the *Index Glass*, attached to the arm IL which carries a vernier, and which moves along the graduated limb BC; the other H, called the *Horizon Glass*, rigidly attached to the frame of the instrument. A telescope is also attached to the frame and points into the horizon

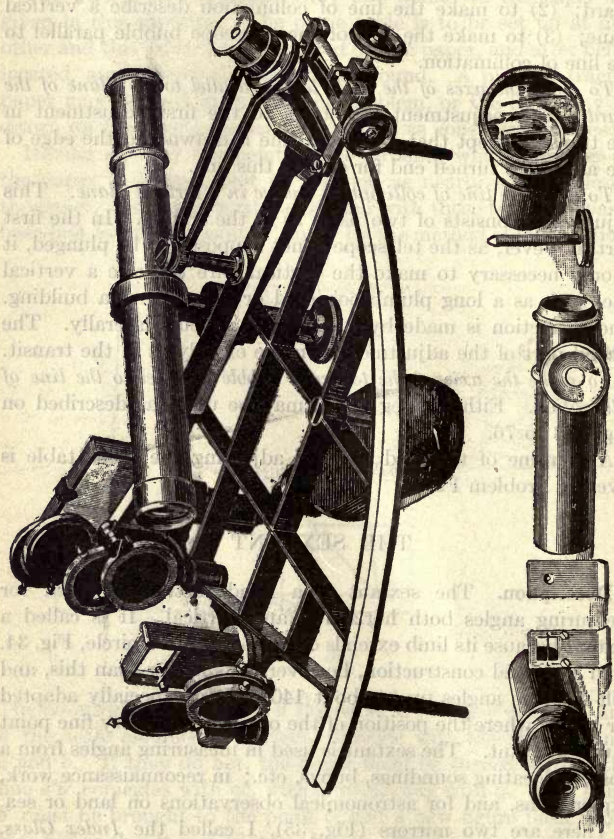


FIG. 34. The Sextant.

glass. The horizon glass is silvered on the lower half, and clear on the upper half.

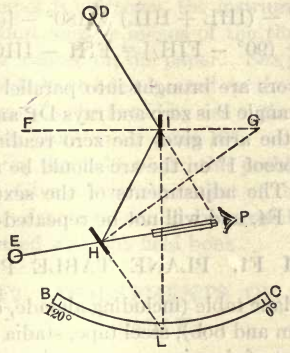


FIG. 35

To Measure a Horizontal Angle. Bring the plane of the sextant into the plane of the two objects (D and E) to be sighted, and sight the telescope toward the fainter object (this may sometimes require that the instrument be held face downward). Move the instrument arm, IL, along the limb so that the image of D reflected from I to the lower half of the horizon glass appears superimposed upon E. The exact coincidence is made by clamping the vernier and by using the tangent screw.

The reading on the limb, corrected for the index error, gives the value of the angle.

Theory of the Sextant. "If a ray of light is reflected successively from two plane mirrors, the angle between the first and last directions of the rays is twice the angle between the plane of the two mirrors." The proof of this is as follows: In the figure, FG and HG are perpendicular to the plane of the mirrors. The ray of light from D is reflected from I to H and then through the telescope to P. The angle between the mirrors is HLI and that between the objects is DPE. Since the angle of incidence equals the angle of reflection,

$$DIF = FIH \text{ and } IGH = GHP.$$

Now $$DPH = DIH - IHP = 2\,(FIH - IHG);$$

also

$$HLI = 180° - (IHL + HIL) = 180° - [(90° + IHG) + (90° - FIH)] = FIH - IHG.$$

When the mirrors are brought into parallel planes, the angle L is zero, and the angle P is zero and rays DP and EP are parallel. This position of the arm gives the zero reading of the vernier. From the above proof 1° on the arc should be marked 2°.

Adjustments. The adjustments of the sextant are given in detail in Problem F4, and will not be repeated here.

PROBLEM F1. PLANE TABLE PRACTICE

Equipment. Plane table (including alidade, compass and level box, plumbing arm and bob), steel tape, stadia rods, hatchet and stakes. Also sheet of drawing paper, engineer's scale, triangles, and irregular curves.

Definitions. The method of *radiation* consists in locating a point by an azimuth from a given line, and a distance from a given station. The method of *intersection* consists in the location of a point by knowing the direction of the point from the two ends of a given base-line.

The method of *traversing* is similar to that pursued in traversing with the transit, except that the courses are plotted directly without taking notes.

Problem. *To survey an area by use of the three methods given above.*

Method. Lay off a base line from 200 to 500 ft. in length. Assume a convenient scale and plot this base line. Set up the plane table over one station and orient it with respect to the other station. Locate any desired object by an angle and a distance (radiation), or by drawing lines of indefinite length toward different objects. Then set up over the other end of the base line, and having oriented the table, check the position of the points obtained by the method of radiation, by the method of intersection. Make a complete plot of the structures or natural objects within the enclosure. The property lines may

be obtained either by radiation or intersection, or by the method of traversing, starting with one boundary line as a base line.

If it be desired to set up over any point in the area, whose position on the paper is unknown, the instrument may be set up over the given point and by means of the three-point problem, this point may be located on the paper. See pages 103 and 104.

If only two points have been located on the drawing, the location of a third point may be found by use of the *two-point problem.* For solution of this problem see page 104.

Notes. Enter in the field book, the problem, party, equipment, and date. Give a brief statement of the work performed in the field. The drawings should be carefully and accurately made, and submitted with the field book.

PROBLEM F2. ADJUSTMENTS OF THE PLANE TABLE

Equipment. Plane table (including alidade, compass and level box, plumbing arm and bob), steel tape, stadia rods, hatchet and stakes.

Outline. Make or test the adjustments as described on page 105.

Report. Give a concise statement of what was actually done in the field, similar to the report on level and transit adjustments.

PROBLEM F3. USE OF THE SEXTANT

Equipment. Sextant (and several range poles if so directed by the instructor).

Problem. *To measure the angles between permanent objects or to close the horizon, using range poles with varicolored flags as sights.*

Theory. The principle upon which the sextant is constructed is that if a ray of light is reflected successively between two plane mirrors, the angle between the incident and reflected rays is double the angle of the mirrors.

Method. Either measure the angles at a certain station between several permanent objects, or set six range poles about a central point so that they will subtend angles approximately 60°

in magnitude, and be at least 200 ft. from the central point. Measure each of the angles at least six times by use of the sextant.

The method of procedure is as follows: Hold the plane of the instrument in the plane of the observer's eye and the two points sighted at. Point the telescope at the fainter object, and bring the image of the other object directly over it by moving the vernier arm. Clamp the movable arm, and bring the two objects to exact coincidence by use of the tangent-screw. If the brighter object is to the right of the fainter one the instrument must be direct, and if to the left, the instrument must be held upside down.

To secure good results the following points should be noted: (1) The index error should be applied (see next problem). (2) The instrument should be held as near the central point as possible at each observation. (3) Unless the objects are in the same horizontal plane the angles will not sum up to 360°.

Modification. The sun's altitude may be measured by use of the sextant. When the sun is on the meridian, the measured altitude, corrected for refraction, index error, etc., may be determined, and knowing the declination of the sun, the colatitude of the place may be found.

PROBLEM F3. USE OF

Angle.	Vernier	Mean Vernier	Index Error.	Corrected Mean Ang	Remarks.
AOB	24°16'10"				
	16'00"				
	16'20"				
	16'10"	24°16'10"	0'20"	24°16'30"	
BOC	71°12'50"				
	13'00"				
	12'40"				
	12'50"	71°12'50"	0'20"	71°13'10"	

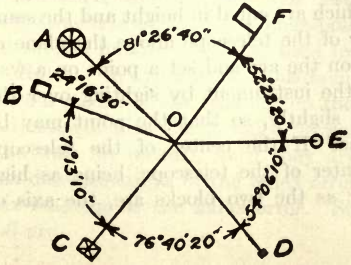
And so on, closing horizon with 5 or 6 angles.

Sum of angles = 360°05'10"

Error = 05'10"

THE SEXTANT.

June 17, 1914. Sextant #3. A. G. Almy, - Obs.



A - Spire of church cor. X. & Y. Sts.

B - Corner of bld'g cor. 1st & 2nd Sts.

C - Center spire of City Hall.

PROBLEM F4. THE ADJUSTMENTS OF THE SEXTANT

Equipment. Sextant.

Method. The adjustments of the sextant are four in number: 1st. To make the plane of the index-mirror perpendicular to the plane of the arc. 2d. To make the plane of the horizon-glass perpendicular to the plane of the arc. 3d. To make the axis of the telescope parallel to the plane of the arc. 4th. To determine the index error.

1. *To make the plane of the index-mirror perpendicular to the plane of the arc.* Place the arm of the instrument about in the middle of the arc, and set the instrument on a stable support. Place the eye so that the direct and the reflected image of the arc scale may be seen joining each other in the index glass. If they do not form one straight arc, tip the mirror either backward or forward by use of the adjusting-screw under the mirror. It may be necessary to slip some paper or tracing-cloth under the arm attached to the mirror in order to make the sextant hold this adjustment.

2. *To make the plane of the horizon-glass perpendicular to the plane of the arc.* This observation is best carried out by sighting on a star. Place the arm so that it reads zero on the arc; hold the instrument so that the plane of the arc is vertical, and slide the arc backward and forward by slow motion. If the instrument is out of adjustment in this respect, the direct and reflected images will not coincide, but the reflected image, as the arm moves, will be slightly above or below the direct image. Adjust the horizon-glass so that the two images coincide when the reflected passes the direct in moving the arm.

3. *To make the axis of the telescope parallel to the plane of the arc.* Prepare two blocks which are equal in height and the same as the height of the center of the telescope above the plane of the arc. Place the blocks on the arc and set a point on a wall about 25 to 30 feet from the instrument by sighting over the blocks. Move the sextant slightly, so that the point may be seen through the telescope. If the center of the telescope traverses the point, the center of the telescope, being as high above the plane of the arc as the two blocks are, the axis of

the telescope is parallel with the line of the blocks, and, therefore, parallel with the plane of the arc. If the axis of the telescope does not traverse the point, adjust the collar attached to the telescope until the axis does traverse the point. Some sextant telescopes are equipped with cross-hairs, which are at the same distance from the axis of the telescope and which may be made parallel to the plane of the arc. When making the adjustment by means of this telescope, place it in the collar of the sextant and make the cross-hairs parallel to the plane of the arc. Sight on an object, such as a slender rod, some distance away, and make the images stand one over the other on one wire. Then move the sextant so that the images are on the other wire. If they stand one directly over the other, as before, the instrument is in adjustment. If they do not, adjust the collar by trial until they hold the same relative position when seen on both wires.

4. *To determine the index error.* When the direct and the reflected image of a distant object, as a star, are seen one superimposed on the other, the zero of the vernier should coincide with the zero of the scale. If they do not coincide, the distance from one zero to the other is called the "index error." The sextant is equipped with adjusting-screws for making the two coincide, but it is better to adjust the instrument so that this error is small, and then note whether the error is "on arc" or "off arc," and apply the index error to the readings of all angles taken with that particular instrument. The sextant is graduated for several degrees on the lower side of zero, so that this index error can be read on both sides of the zero-mark. The index correction is "on arc" when it is on the main scale, and is then *minus*; it is "off arc" when it is on the extension of the scale, and is then *positive*. The best object to use in making this adjustment is a star, but a range-pole may be set up at a distance of several hundred feet and used for making the adjustment.

Notes. In making the adjustment of a particular instrument, give a record of the readings on the several trials; in the third adjustment give the distance between the two lines of sight on the wall (in inches), until they are made to coincide. Make six determinations of the index error, and take the mean of the six readings as the index error. State whether it is on arc or off arc.

CHAPTER VIII

THE ANEROID BAROMETER AND THE PLANIMETER

THE ANEROID BAROMETER

The *aneroid barometer* consists of a circular metallic box, hermetically sealed, and one side covered by a corrugated plate. The air has been partially exhausted, enough being left in to compensate for the effect of temperature on the plate itself. The cover rises or falls as the air pressure becomes less or greater, and this movement is multiplied and transmitted over a scale on the outer face. The scale is graduated in inches corresponding to the heights of a mercury column.

Uses of the Aneroid. The aneroid barometer is especially adapted to reconnaissance and exploratory work. With care, it is capable of giving results within one to ten per cent. The particular advantage in its use is rapidity.

Theory. The student is referred to the larger treatises on surveying for the theory of the aneroid. A *brief* statement of the theory will be found in Problem G1.

THE POLAR PLANIMETER

The *planimeter* is an instrument used for measuring areas that have been previously drawn to scale. There are three kinds of planimeters, the polar, the suspended, and the rolling planimeters. The polar planimeter is most commonly encountered in practice.

Theory. In describing a closed figure with the fixed point of the planimeter outside the figure, the area described is equal to the product of the roll of the wheel times the length of the arm. When the fixed point is inside the figure, the area of the zero circumference must be added to the roll of the wheel.

There are three motions for the planimeter: First, where the angle *dce* in Fig. 36 is 90°, the motion of the wheel at *c* will be along its axle and, consequently, there will be no record.

If this angle remains at 90° a circle will be described by *d*

and this circle is called the *zero circumference*. It can thus be seen that when the fixed point of the planimeter is inside the area that part of the area within the zero circumference will not be recorded.

Second, when the point d is outside the zero circle, the motion in a clockwise direction will be positive, and the second reading will be greater than the first.

Third, when d remains within the zero circumference the record in a clockwise direction is negative and the second reading on the wheel will be less than the first.

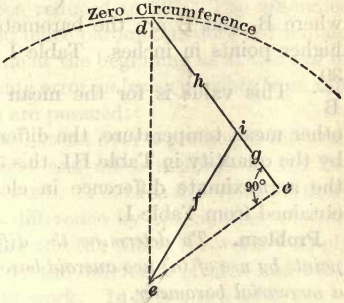


FIG. 36

In order to see that the motions of the wheel are correctly summed for all motions, it is advised that four figures be constructed, the first three conforming to the three motions above described, and the fourth where the area described is partly inside and partly outside the zero circumference. In this connection it should be remembered that the area obtained by the wheel is that lying between the path described by the movable point and the zero circumference. Problem G2 fully explains how the constants of the planimeter are obtained or checked, and how it is used in an actual example.

PROBLEM G1. ELEVATIONS BY USE OF THE ANEROID BAROMETER

Equipment. Two aneroid barometers, two thermometers and watches; or one aneroid barometer, a mercurial barometer, and thermometers.

Theory. The use of the barometer to determine differences of elevation depends upon the supposition that the atmosphere is composed of a series of layers of air, which decrease uniformly in density as the altitude increases. Practically, this is not true,

and a correction must be applied for temperature and humidity. A common formula for the difference in elevation is:

$$\text{Difference in elevation} \left(\text{in feet}\right) = 62737 \left(\log \frac{30}{B_1} - \log \frac{30}{B}\right)$$

where B_1 and B are the barometer readings at the lower and higher points in inches. Table I gives the quantity 62737 log $\frac{30}{B}$. This value is for the mean temperature of 50°; for any other mean temperature, the difference in elevation is corrected by the quantity in Table III, this correction being multiplied by the approximate difference in elevation of the two points as obtained from Table I.

Problem. *To determine the difference in elevation of several points by use of* (*a*) *two aneroid barometers, and* (*b*) *an aneroid and a mercurial barometer.*

(*a*) Owing to the greater cost and non-portability of the mercurial barometer, two aneroid barometers are sometimes used. One aneroid is left in the office and readings are taken at definite times, and the temperatures are noted. Before going into the field readings are taken in the office on both the field and office aneroids. The time and temperature are noted. The field aneroid is then taken to the different points whose elevations are desired. The barometer is read, also the temperature, and the time is noted.

When the points differ much in elevation the aneroid will lag, and the observer should wait at the station for a reasonable time before taking the reading. It is recommended that they be taken on the five minute intervals, in order that they may be combined with the office aneroid readings, which are taken every five or ten minutes. After the field work is completed, the office and field aneroids are compared at headquarters, and a note made of the time.

(*b*) When the mercurial barometer is used as reference, its attached thermometer is read and the mercurial reading reduced to 32° by use of Table II. The elevation obtained by reducing this reading is practically the absolute elevation of the point above the sea level, and after the difference in elevation of the office and field points has been found, the absolute elevations of the

field points may be determined. When two aneroids are used, the *relative* differences in elevation are found.

Computations. The matter following refers more particularly to (*a*) above, but the method of procedure in (*b*) is similar, after the mercurial column has been reduced to 32°. The difference in the readings of the field and office barometers does not remain constant, i.e., it is not the same at the beginning as at the end of the work. In order to eliminate error as far as possible from this source the following methods are pursued:

First, when the observations extend over a prolonged interval. Find the difference of the field and office readings at the beginning and at the end of the work. Find the difference of these two quantities. Divide this difference by the number of time intervals between the beginning and the end of the work. Apply this as a constant increment to the difference of field and office aneroids at the beginning of the work. In this way a table can be constructed which will give corrections to the field barometer readings at the different times. These corrections are applied to the proper field readings. Elevations corresponding to the office readings and the corrected field readings are found from Table I. The difference in elevation of two readings taken at the same time will give the approximate difference in elevation of the points. This approximate difference is multiplied by the temperature coefficient as found in Table III, and the product is applied to the approximate difference in elevation giving the true difference in elevation.

This method is the one used in the sample notes below, and should be clearly understood by inspection.

Second, when the time interval between the first and last readings is only one or two hours. Find the difference of the field and office readings at the beginning and end of the work. Compute the mean difference. Apply this mean difference to the field reading in order to reduce both barometer readings to the same plane of reference, and proceed with the reductions as before.

PROB. 61. ELEVATIONS BY

Station.	Field Read.	Correct. Field Read.	Elev. Corresp. to Corr. Field Read.	Elev. Corresp. to Office Aneroid	Correct-ion.
Office	29.590	29.410	540.8		
1.45 52°					
Δ 1	29.670	29.491	467.2	531.6	+.1
1.55 50°					
Δ 2	29.617	29.439	514.1	531.6	0
2.05 49°					
Δ 3	29.677	29.500	458.0	531.6	+.3
2.10 49°					
Δ 4	29.612	29.435	517.8	542.4	0
2.15 49°					
—	And so on				
—					
—					
—					
—					
—					
Office	29.633	29.460	494.8		
3.05 49°					

THE ANEROID BAROMETER.

True Diff. of Elev.	Elev.	
		Party, date, equipment, etc. as usual.
		Stations:
		$\Delta 1$ = Small nut on hydrant
-64.5	498.4	N.E. cor. June + Day Sts.
		And so on.
-17.5	545.4	Office Aneroid.

		Time	Temp.	Read.
-73.9	489.0	1.45	48°	29.41
		1.55	47.5°	29.42
-24.6	538.3	2.05	47.5°	29.42
		2.10	50°	29.42
		—	And so on	
		3.05	46°	29.46'

Table for Reduction of Field Readings to Datum of Office Readings

Time		Correction
1.45	(29.410-29.590)	= -.180
1.55		-.179
2.05		-.178
2.10		-.177
—	And so on.	
3.05	(29.460-29.633)	= -.173

PROBLEM G2. THE POLAR PLANIMETER

Equipment. Polar planimeter, set of drawing instruments, triangles, scale, and sheet of paper about 15 inches square.

Problem. *To check the constants of the planimeter, and then to find the area of an irregular figure.*

Theory. In tracing a closed figure with the fixed point of the planimeter outside the figure, the area of the figure is equal to the roll of the wheel times the length of the arm. When the fixed point is inside the figure the area of the zero circumference must be added.

Method. Draw a four inch square, a six inch square, a circle of four inch diameter, and a circle of six inch diameter, so placed that when the fixed point of the planimeter is inside the six inch figure, the rolling wheel will stay on the paper. Designate the figures as 1, 2, 3 and 4. Set the slide index opposite the 10□″ graduation on the bar. This equals ten times the number of revolutions of the wheel, or, in the formula $A = hnc$, hc becomes 10, whence $A = 10n$.

Traverse each figure with the fixed point of the planimeter outside. The initial reading a is noted, and after traversing the figure, the reading b is taken. The figure is again traversed, and a reading c taken. Find $(b - a)$ and $(c - b)$.

To find "area by planimeter" take the mean in columns 5 and 6 for each plot and multiply this mean by 10. The true area of each plot is found by the rules of geometry.

Take similar readings on a six inch circle, with the fixed point of the planimeter inside the circle. Before entering the values $(b - a)$ and $(c - b)$ add to each the number on top of the bar just over the 10□″ graduation. This number is one-tenth the area of the zero circumference. Then, if Z denotes the area of the zero circumference,

$$A = 10n + Z = 10\left(n + \frac{Z}{10}\right).$$

Note that $(b - a)$ is *negative* if motion is *clockwise;* also, that the wheel will turn more than ten times in going around a six inch circle.

With the index still set at the 10 □″ graduation, measure as nearly as possible the distance from the fixed point to the tracing point when the wheel only slides; that is, when the motion is entirely parallel to the axis of the wheel. This is the radius of the zero circumference. Designate this reading as R, and record it on the right-hand page of the field book. Then $\frac{\pi R^2}{10}$ should be a rough check of the number on top of the bar.

Assume that the four inch square represents a plot of ground at the scale of $\frac{1}{8}'' = 1'$. Set the index at 400 □′ $\frac{1}{8}'' = 1'$. This means that if the scale is $\frac{1}{8}'' = 1'$, A in square feet equals 400 n. Enter this computation as 1′.

Lay off any convenient length of arm, h, and traverse a known area, noting the number of turns, n, of the wheel. The circumference of the wheel, c, may then be found from the equation $A = hnc$, where A is the area described. Record the results on the right-hand page. This value is often given by the maker.

Area of an Irregular Figure. Having obtained the area of an irregular figure by calculation, check it by the use of the planimeter.

The plot of any survey may be traversed with the planimeter, the calculated area being checked by the area obtained by the planimeter; especially any survey of an area where one or more sides are bounded by streams.

PROB. 62. THE POLAR PLANIMETER.

(Notes extend across both pages.)

Figure	a.	b.	c	(b-a)	(c-b)	Area by plan.	True Area

On right-hand page give the usual information together with the special points noted in the text of this problem.

CHAPTER IX

RAILROAD CURVES

Railroad curves are in general arcs of circles. The *degree of curve* is the angle subtended at the center by a chord of 100 ft. A curve is designated by its degree or by its radius. The flat curves in use on steam railroads are designated by the degree, and the sharp curves in cities, on electric railways, are designated by their radius.

Simple Curve. A simple curve is a curve of a single radius connecting two tangents. In Fig. 37, the different parts of the

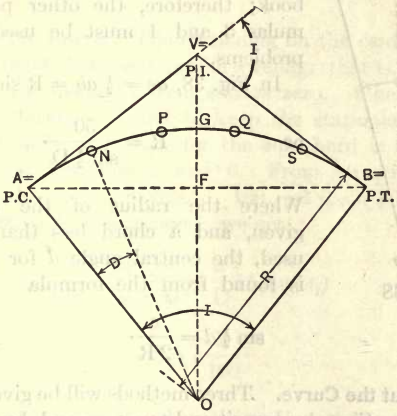


FIG. 37

curve are designated as follows: The lines AV and BV are called tangent distances or "tangents," T. The distance AB is the *long chord*, C, of the curve; FG the middle ordinate, M; and GV the external distance, E; AO the radius, R. The ex-

ternal angle at V between the tangents is the intersection angle, I, which equals the central angle of the curve AOB. From the figure the following equations may be deduced:

$$AV = T = R \tan \tfrac{1}{2} I. \quad (1)$$

$$AF = \tfrac{1}{2} C = R \sin \tfrac{1}{2} I, \quad \text{or} \quad C = 2R \sin \tfrac{1}{2} I. \quad (2)$$

$$FG = M = R - OF = R - R \cos \tfrac{1}{2} I = R (1 - \cos \tfrac{1}{2} I)$$
$$= R \operatorname{vers} \tfrac{1}{2} I.$$

$$VG = E = VO - R = R \sec \tfrac{1}{2} I - R = R (\sec \tfrac{1}{2} I - 1) \quad (3)$$

$$= R \operatorname{exsec} \tfrac{1}{2} I. \quad (4)$$

The functions versine and exsecant are of great service in curve computation. Special tables including them are given in most of the railroad field books. It is not deemed best to include them in this book; therefore, the other parts of formulas 3 and 4 must be used in solving problems.

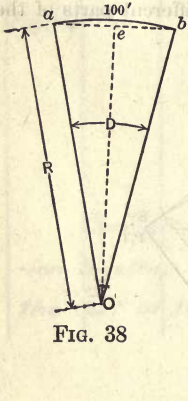


FIG. 38

In Fig. 38, $ae = \tfrac{1}{2} ab = R \sin \tfrac{1}{2} D$,

or
$$R = \frac{50}{\sin \tfrac{1}{2} D}. \quad (5)$$

Where the radius of the curve R is given, and a chord less than 100 ft. is used, the central angle d for the chord c is found from the formula

$$\sin \tfrac{1}{2} d = \frac{c}{2R}. \quad (6)$$

Laying Out the Curve. Three methods will be given for laying out a curve. First, by transit and tape; second, by offsets from the tangents; and third, by offsets from the chords produced.

Curve by Transit and Tape. The usual method for laying out a curve is by deflection angles from the tangent and distances from station to station. The solution may be explained by referring to the figure.

Lay off the tangent distances, locating the P.C. and P.T. Set the transit up at the P.C.; set vernier A at zero; sight along AV,

clamping the lower motion (Fig. 37). Lay off the deflection to the point N, the proper distance AN being given by the tape. This deflection is half the central angle for this chord. Then lay off the deflection VAN, which is half the central angle AON. Proceed in a similar way until the P.T. is reached.

It is always best, if possible, to set the P.T. from the P.I. When the P.T. is visible from the P.C., the deflection angle P.I. — P.C. — P.T., should be checked before any stakes are set on the curve. This method is treated in Problem H1.

Length of Curve. The length of curve $L = 100\frac{I}{D}$, or in case a chord less than 100 ft. is used the formula becomes

$$L = c\,\frac{I}{d}. \tag{7}$$

Stationing the Curve. The stationing on the center line of a railroad is carried along as in profile leveling; that is, the station numbers are the distances from station zero. Where the P.C. is at a plus station, in order to keep the stationing at whole numbers, the deflection angle for the sub-chord is found by a combination of formulas 5 and 6. From equation 6, $c = 2\,R \sin \frac{1}{2}\,d$ and from equation 5, $100 = 2\,R \sin \frac{1}{2}\,D$, whence, dividing equation 6 by equation 5, we get

$$\frac{c}{100} = \frac{\sin \frac{1}{2}\,d}{\sin \frac{1}{2}\,D} = \frac{d}{D}\ \text{(Approx.)}$$

or

$$d = c\,\frac{D}{100}. \tag{8}$$

With very sharp curves, when the radius of the curve R, is given, a chord c' less than c may be necessary in order to keep the stations on the curve correct. In this case, formula 8 becomes

$$d' = \frac{c'd}{c}, \tag{9}$$

where d' = the central angle for the chord c'.

Offsets from the Tangent. This method is fully outlined in Problem H3.

Offsets from the Chords Produced. This method of locating a simple curve is also treated in Problem H3.

Compound and Other Curves. It is not the province of this book to go into the theory of railroad curves to any appreciable extent. The reader is referred to any one of the numerous railroad curve field books for more complete information on this subject.

PROBLEM H1. SIMPLE CURVE WITH TRANSIT AND TAPE

Equipment. Transit, 100-ft. steel tape, two range poles, set of marking pins, two plumb-bobs, hatchet, stakes and tacks.

Problem. *To lay out a simple curve with transit and tape having given the degree or radius of the curve, the central or intersection angle I, and the station of the P.C.*

Method. Compute the tangent distance, and a complete table of deflections for staking out the curve from the P.C. applying the check that the last deflection should equal $\frac{1}{2}$ I. Set a stake at the P.I. and lay off the tangent distances in suitable directions, so that they make an angle I with each other. Set up the transit at the P.C. and after checking the angle P.I. — P.C. — P.T., stake out the curve.

Note the error in line and distance. This should be a reasonably small error, depending upon the length of the curve and other conditions. Keep the P.T. as first located.

Transit station on curve. Assume that the P.T. of the curve cannot be seen from the P.C. Line out the curve to a designated station. Set up the transit at this station, and stake out the remainder of the curve. To find the tangent to the curve at this intermediate station, sight at any transit station on the curve, with the deflection of that station set off on the proper side of zero; plunge the telescope, and continue as if at the P.C. of the curve. Note the error in line and distance between the P.T. which was first set and that found from the intermediate set-ups.

Reference-stakes should be placed at one side of all transit

stations, and should give, on the front of the stake, the number of the station and whether stake is P.C. or P.T.; and on the back, the degree of curve and its direction. All other stations should be marked from top to bottom, the numbering being visible as one walks along the line from zero.

Remark. The above problem may be modified to suit conditions which arise in actual practice.

PROBLEM H1.

Station	Points	Desc. of Curve	Total Deflect.	Mag. Bearing	Calc Bearing
	⊙+37.5 P.T.		11° 15′		
20			10° 30′		
19		R=1432.69	8° 30′		
18		T=285.00	6° 30′		
	⊙+60.0 P.I.				
17		L=562.5	4° 30′		
16		I=22° 30′	2° 30′		
15		4° Right	0° 30′		
	⊙+75.0 P.C.				
14					

Error in measure. = +.1′. Error in angle = None

SIMPLE CURVE.

Party, date, equipment, etc. as usual.

T, 22° 30′ = 1139.7 | 4

284.925

Corr. = .055

T_4 = 284.980

$L = 100 \frac{22.5}{4}$

L = 562.5

Deflection to Sta. 15 = 25 X .3 X 4 = 30′.

" " " P.T. = 37.5 X .3 X 4 = 45′.

P.C. = P.I. − T = (17+60) − (2+85) = 14 + 75.

P.T. = P.C. + L = (14+75) + (5+62.5) = 20+37.5

PROBLEM H2. SIMPLE CURVE, *P.I.* INACCESSIBLE

Equipment. Transit, 100-foot steel tape, two range-poles, set of marking-pins, hatchet, two plumb-bobs, stakes, keil, and tacks.

Problem. *Given two tangents and any number of intervening traverse lines (one traverse line is used in this problem), to connect the tangents by a simple curve of given degree, the P.I. being inaccessible.*

Method. Solve the triangle VBC for VB and VC, knowing the deflection angles at B and C and the chord BC. Assume

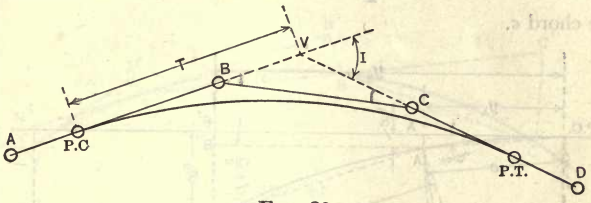


FIG. 39

D, calculate T, and lay off the difference between T and BV to locate the P.C. and T and VC to locate the P.T. Line for the hubs which determine the P.C. and the P.T. is given by setting up the transit at stations B and C.

Example. Given BC = 230.0 feet, angle B = 10° 05′, angle C = 7° 35′, D = 4° 00′, and station of B = 22 + 50.

Answer. T = 222.64, BV = 100.02, VC = 132.69, sta. P.C. = 21 + 27.38.

Remark. The above example may be modified either by changing the given data or by increasing the number of traverse lines. In the latter case there will be one triangle to solve for each traverse line.

Notes. Similar to those in the preceding problem for the left-hand page, and for the right-hand page a sketch similar to that given above, together with the principal computations; also error, party, date, equipment, etc., as usual.

PROBLEM H3. LOCATION OF A SIMPLE CURVE BY USE OF TAPE ALONE

Equipment. Two range-poles, 100-ft. steel tape, a 50-ft. cloth tape, set of marking pins, plumb-bobs, hatchets, stakes, and tacks; also a transit to set the P.C. and the P.T., if so directed by the instructor.

Problem. *First, to locate a curve by offsets from the tangents; second, to locate the same curve by offsets from the chords produced.*

Theory. Offsets from the Tangents. In the figure the distance $AA' = x_A = c \sin \frac{d}{2}$ where d equals the central angle for the chord c.

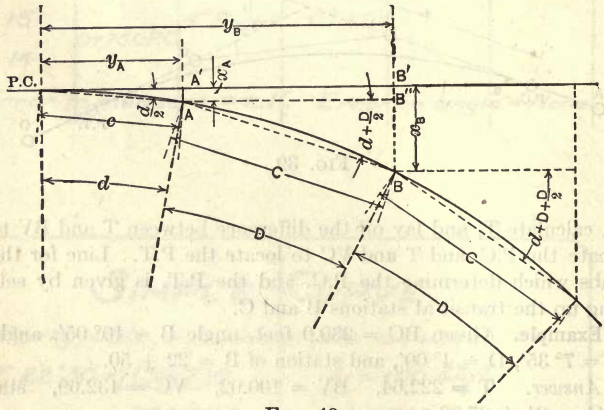


FIG. 40

$y_A = c \cos \frac{d}{2}$. For the point B, the angle $B''AB = d + \frac{D}{2}$, where D equals the degree of curve, and the distance $BB'' = 100 \sin \left(d + \frac{D}{2}\right)$. The distance $B'B = B'B'' + B''B$. The distance $AB'' = 100 \cos \left(d + \frac{D}{2}\right)$, and the distance $y_B = y_A +$

AB″. The distances x and y for the other points may be found in a similar way.

Offsets from the Chords Produced. When the curve begins with a sub-chord. In the figure, the distance $AA' = \frac{c^2}{2R}$. A distance equal to AA′ is laid off at the P.C. and the line joining this point and A is a common tangent to the curve at the point A. The distance $BB' = \frac{100^2}{2R}$, where AB = 100 ft. and the angle AB′B = 90°. The distance CC′ = 2 BB′ and BC′ = BC = 100 ft. Similarly for other points.

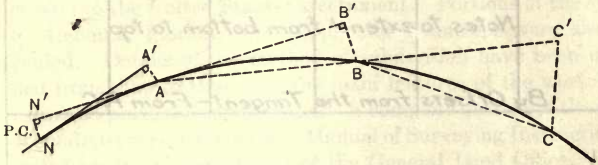


FIG. 41

In order to determine the direction of the tangent to the curve at the P.T., the method pursued at the P.C. is reversed.

Field Work. Having set the P.C. and P.T., locate the points on the curve, first by tangential offsets. The angles at A′ and B′ are right angles. The cloth tape is used to get the offsets. The points A′, B′, etc., are lined in by the eye. If the curve is long, there will be a saving of time by locating the last part of it from the P.T. instead of prolonging the first tangent beyond the P.I.

Second, locate the curve by offsets from the chords produced. When the curve begins with a sub-chord, the first two points are located by offsets from the tangents. The method of procedure is evident from an inspection of the figure. The chord offset for a full station is twice the tangential offset for a full station. A given point can best be located by an offset from the chord produced when the preceding chord is a full chord in length. When this is not the case, locate by offset from the tangent at the preceding station.

PROB. H3. SIMPLE CURVE

Station	Points	Desc. of Curve	∝	x	y

By Offsets from the Tangent – From P.T.

Notes to extend from bottom to top.

By Offsets from the Tangent – From P.C.

By Offsets from the Chords Produced.

BY TAPE ALONE.

Total x	y.

Party, date, equipment, etc. as usual.

Give brief summary of computations.

CHAPTER X

THE UNITED STATES SYSTEM OF LAYING OUT THE PUBLIC LANDS

System. The United States system of surveying the public lands was inaugurated about 1785. The area included was that portion of the country north of the Ohio and west of the Mississippi Rivers not owned by individuals previous to the dates of cession to the United States Government. Portions of the states of Alabama, Florida, Mississippi, and Tennessee were also included. Details of the method of subdivision have been modified from time to time, but the main features of the work have remained practically unchanged. A complete outline of the work of subdivision is given in the "Manual of Surveying Instructions," issued by the Commissioner of the General Land Office, Washington, D. C.

The work of subdivision proceeded slowly, progressing only as demand for land was made. Unfortunately many of the early surveys were made by contract, and the work was very poorly performed, in some cases the field work not actually being done.

The law required that the land should be divided by north and south lines run according to the meridian, and by others crossing them at right angles, so as to form townships six miles square; also that the townships should be divided into thirty-six sections, each containing six hundred and forty acres. This was to be done by a system of parallel lines, one governed by true meridians and the other by parallels of latitude, intersecting each other at right angles at intervals of one mile.

It is evident that on account of the convergence of the meridians, it is impossible for the townships to be six miles square. The same is true for the division of the townships into sections. Therefore, it was necessary that one or the other of the requirements be modified. In the division into townships, the east and west lines of the township are true meridians, conse-

quently the length of the north line of a township is less than that of the south. In the subdivision of a township into sections, the interior lines are made parallel to the *east line* of the township, and neglecting errors in surveying, there will be thirty sections, each one mile square. The law specifies that errors and discrepancies shall be thrown into the *westerly* and *northerly* sections. It is for this reason that the work of subdivision of a township into sections starts from the east side of the township.

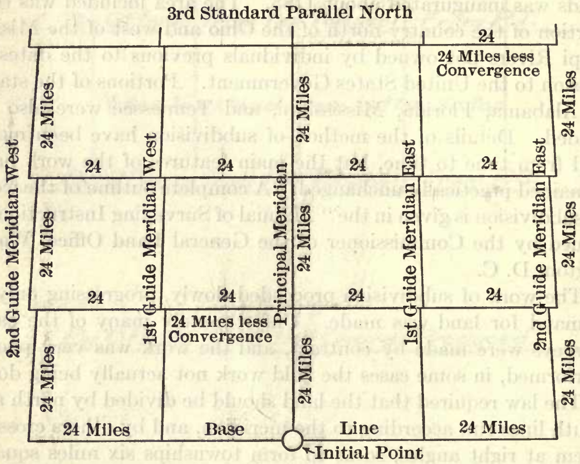


FIG. 42

Details of the System. The work of subdivision is carried on as follows:

First, establish an *initial point* from which to start the survey;

Second, establish a *principal meridian* passing through the initial point;

Third, establish a *base line* conforming to a parallel of latitude, passing through the initial point, and extending both east and west from it;

Fourth, at 24-mile intervals on the base line, establish *guide meridians* which are true meridians;

Fifth, at 24-mile points on the principal meridian, establish *standard parallels.*

The area will then be divided into tracts approximately 24 miles square, as shown in Fig. 42.

Division into Townships. The 24-mile tracts are divided into townships by projecting true meridians and parallels of latitude at the six-mile points. (Fig. 43.) The upper line of a township

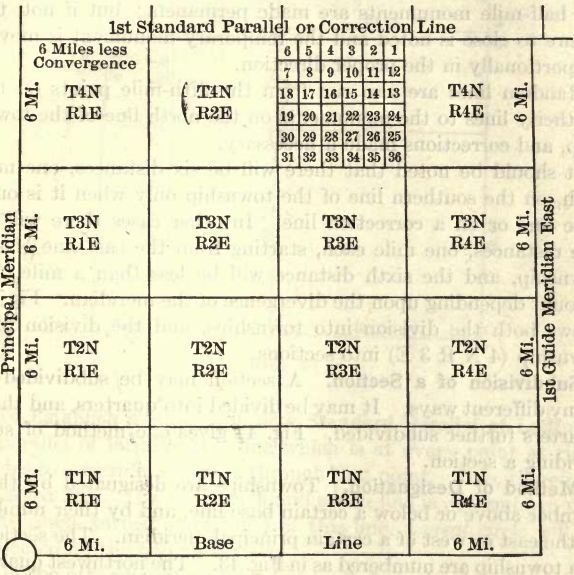


FIG. 43

will be shorter than the lower line on account of the convergence of the meridians. When the standard parallel or *correction line* is reached, the division into townships starts anew with six-mile distances laid off on the correction line. There will then be two sets of monuments on this line; one for the townships south of the line, and the other for those north.

Subdivision of a Township. A township is divided into sections by laying off distances of one mile each on its southern line, and from these points lines are run northerly and parallel to the east boundary. One-mile distances are laid off on these north lines. Random lines are run easterly from the one-mile points on each northerly line toward corresponding points to the east. Temporary monuments are set at half-mile intervals along these lines, and if a line strikes the section monument previously set, the half-mile monuments are made permanent; but if not, the failure to close is noted and the temporary monument is moved proportionally in the proper direction.

Random lines are also run from the fifth-mile points on the northerly lines to the monuments on the north line of the township, and corrections made if necessary.

It should be noted that there will be six distances, one mile each, on the southern line of the township only when it is on a base line or on a correction line. In other cases there will be five distances, one mile each, starting from the east line of the township, and the sixth distance will be less than a mile, the amount depending upon the divergence of the meridian. Fig. 43 shows both the division into townships, and the division of a township (4 N R 3 E) into sections.

Subdivision of a Section. A section may be subdivided in many different ways. It may be divided into quarters, and these quarters further subdivided. Fig. 44 gives one method of subdividing a section.

Method of Designation. Townships are designated by their number above or below a certain base line, and by their number to the east or west of a certain principal meridian. The sections in a township are numbered as in Fig. 43. The northwest quarter of a certain section might be designated as N. W. $\frac{1}{4}$ Sec. 12, T 3 N, R 2 E, " ....." P.M.

Corners. Many different materials are used for corner monuments. First preference is given to durable stones, then posts, and finally mounds with stake in pit.

Meandering. In order to determine the area of tracts partially covered by water, meander lines are placed along the banks of the body of water and offsets are taken to the high water points.

The meander lines are tied into the main lines of the survey. They are in no case boundary lines, but are used merely as traverse lines. The "Manual of Surveying Instructions" gives a large amount of additional information on this subject.

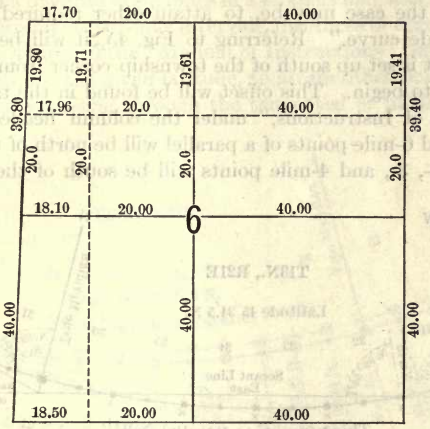


FIG. 44

To Establish a Base Line or a Standard Parallel of Latitude. A parallel of latitude is a line which is at every point at right angles to a meridian passing through that point. It is, therefore, a curved line. If a true north and south line is determined, and a 90° angle turned at one end of this line, a *great circle* will be projected on the earth's surface.

On the other hand, a parallel of latitude is a *small* circle. To obtain a base line or a parallel of latitude, a straight line is projected and offsets are taken from this line to the required curved line.

The principal meridian, which is a true north and south line, is determined as in Problems L1–L4. A standard parallel is found from this meridian either by use of the *secant method* or by the *tangent method*.

The Secant Method. "This method consists in running a connected series of straight lines each six miles long, on such courses that any one of the lines will intersect the curve of the parallel of latitude in two points, separated by an interval of four miles; and from the lines thus established, measuring north or south, as the case may be, to attain other required points on the latitude curve." Referring to Fig. 45, it will be seen that the transit is set up south of the township corner from which the survey is to begin. This offset will be found in the table of the "Manual of Instructions," under the column headed 0 miles. The 0- and 6-mile points of a parallel will be north of the secant, and the 2-, 3-, and 4-mile points will be south of the secant.

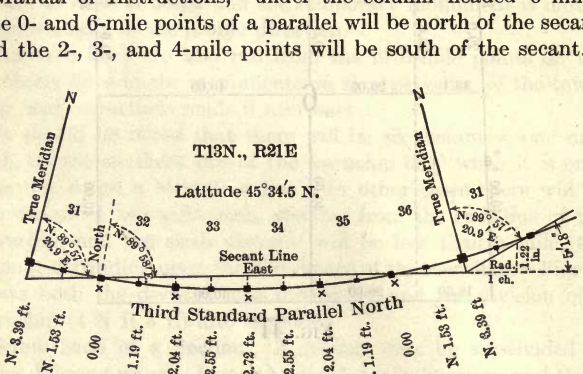


FIG. 45

The instrument is set up at a point on the secant line at the west of the township, a true meridian is established, and the azimuth, as found in the table under "0 miles," is laid off. This secant line is then prolonged 6 miles and a new secant line established. At each mile and half-mile point an offset is measured to establish a point on the parallel. The direction of the new secant may be found by laying off a deflection angle to the north from the former secant. The value of the deflection angle for the particular latitude is found in the table. An observation for meridian must be taken at least every 18 miles.

The particular advantage of the secant method over the tan-

gent method described in the next paragraph, is due to the short offsets and the consequent reduction in cutting and clearing.

The Tangent Method. Fig. 46. "This method consists in laying off from a true meridian, established by observations on Polaris at elongation, an angle of 90°, producing the direction thus determined a distance of six miles in a straight line, and measuring north therefrom, at half-mile intervals, distances of correct length taken from a table in the 'Manual of Instructions' (interpolated if necessary), for the given latitude, to attain other points on the latitude curve passing through the tangential or initial points."

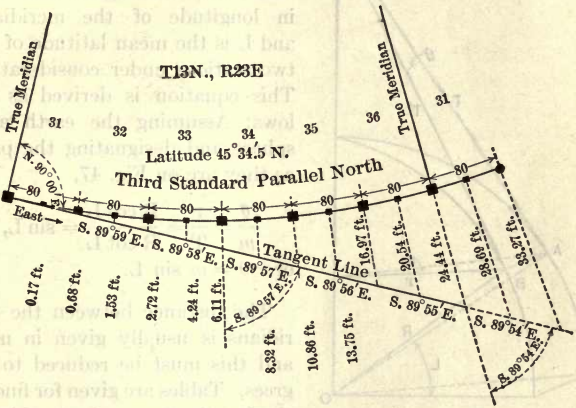


FIG. 46

The azimuth or bearing of the tangent at successive mile points will be taken from the table to the nearest whole minute only, and will be inserted in the field notes, no interpolation being required except when the sights are taken.

The true bearing of the two points on the standard parallel will be derived from the same table by taking it from the column headed with one-half the distance between said points. The offsets at intervals of one mile are inserted in the table; to obtain the length of the offsets at the half-mile points, take one-fourth

the offset corresponding to twice the distance of the half-mile point from the tangential point.

"This method is suitable for running standard parallels and latitude township lines in level, open country, where no intersection with topographical features will be required; but in all cases the secant method will be found most convenient."

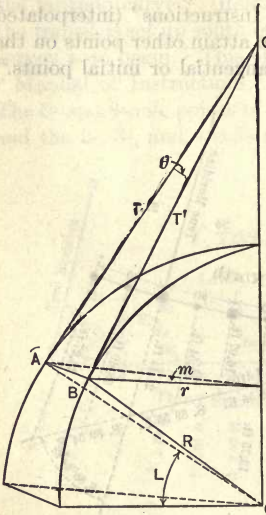


FIG. 47

Angular Convergence of the Meridians. The angular convergence of the meridians is found from the equations $\theta = m \sin L$, where m is the angular difference in longitude of the meridians, and L is the mean latitude of the two stations under consideration. This equation is derived as follows: Assuming the earth as a sphere and designating the parts as they are on Fig. 47,

$$\frac{\theta}{m} = \frac{r}{T} = \frac{R \cos L}{R \cot L} = \sin L,$$

or $\theta = m \sin L$.

The distance between the meridians is usually given in miles and this must be reduced to degrees. Tables are given for finding the length of one minute of longitude for different latitudes. By use of this table the number of degrees of longitude between two meridians may be found and substituted in the formula $\theta = m \sin L$.

PROBLEM 11. CONVERGENCE OF MERIDIANS.

Problem. *To find the angular and the linear convergence of two meridians six miles apart at the latitude of the observer.*

Method. *Angular convergence.* Look up the latitude of the place from some book or map. Obtain from a work on geodesy

the length of 1° of longitude at the given latitude. From this value find the equivalent in minutes, of six miles. Finally substitute in the formula $\theta = m \sin L$, where m = the angular difference in longitude (just found), θ = the angular convergence of the meridians and L = the latitude.

Linear Convergence. The linear convergence in a given length, l, is $c = l \sin \theta$. By substituting values of one mile and six miles in this equation, there are obtained the amounts that the north sides of a section and of a township are shorter than the south sides.

CHAPTER XI

COMPUTATIONS

The area of a piece of land may be found in the following ways. First, by dividing the tract into triangles; second, by finding the lengths and bearings of the boundary lines; third, by coordinates.

AREA BY DIVISION INTO TRIANGLES

By Use of Tape Alone. All sides of the tract are measured, and also the diagonals, or an interior point may be taken and the distances found from this point to each corner. The total area is equal to the sum of the areas of all the triangles. The area of each triangle is found from the formula,

$$\text{the area} = \sqrt{s\,(s-a)\,(s-b)\,(s-c)},$$

where s is the half sum of the three sides a, b, and c, in each triangle.

Two Sides and an Included Angle. The figure may be divided into triangles, and two sides, and the included angle of each triangle measured. The area of each triangle is found by the formula, the area $= \frac{1}{2}\,ab \sin C$, where a and b are the two sides and C the included angle. The sides may be measured by the chain, tape, or by use of the stadia. The interior angles may be found either by the transit or compass.

AREA FROM LENGTHS AND BEARINGS OF BOUNDARY LINES

In this method two common cases arise. First, where the boundary lines are unobstructed; second, where they are obstructed. Where the boundaries are unobstructed the lines are measured directly and the angles are obtained by setting up at each corner in turn. A transit may be used and interior angles

measured, from which the bearings may be computed; or, the bearings may be found directly by use of the compass.

Second, where the lines are obstructed, rectangular offsets are made, and the bearings and lengths of parallel lines are found. The offset lines may be either inside or outside the given area.

Definitions. The *latitude* of a course is the projection of a course on the meridian, or it is equal to the length of the course times the cosine of its bearing.

The *departure* of a course is the projection of the course on an east and west line, or it is the length of the course times the sine of its bearing.

North latitudes are plus, and south latitudes are minus. East departures are plus, and west departures are minus.

The *meridian distance* of a course is the perpendicular distance from the middle of the course to the reference meridian.

The *double meridian distance* of a course is equal to the sum of the meridian distances to the extremities of the course.

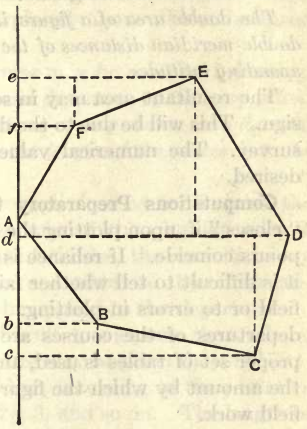


FIG. 48

Derivation of Formula for Area. Let ABCDEF represent a figure whose area is to be computed. The bearings and lengths of all courses have been measured. A meridian is passed through the most westerly point and perpendiculars are let fall from each station to this meridian. Other additional lines are drawn as in Fig. 48.

Then the area

$$\text{ABCDEF} = c\text{CD}d + d\text{DE}e - c\text{CB}b - b\text{BA} - \text{AF}f - f\text{FE}e,$$

or area

$$\text{ABCDEF} = \tfrac{1}{2}(c\text{C} + d\text{D})\,cd + \tfrac{1}{2}(d\text{D} + e\text{E})\,de - \tfrac{1}{2}(c\text{C} + b\text{B})\,cb - \tfrac{1}{2}(b\text{B})\,(b\text{A}) - \tfrac{1}{2}(f\text{F})\,(f\text{A}) - \tfrac{1}{2}(f\text{F} + e\text{E})\,fe.$$

It may be noted that the quantities enclosed in the parentheses are the double meridian distances of the courses, and the distances by which these are multiplied, are the latitudes of the corresponding courses. Inasmuch as the meridian is taken through the most westerly point, the quantities in parentheses are all positive, while the latitudes of the courses CD and DE are positive, and the latitudes of the other four are negative. These signs conform to the rule above stated, viz.: latitudes of north courses are plus, and those of south courses are minus.

Both sides of the equation may be multiplied by two. We may then state the following rule:

The double area of a figure is equal to the algebraic sum of the double meridian distances of the different courses times their corresponding latitudes.

The resultant area may in some cases come out with a minus sign. This will be due to the direction taken in going around the survey. The numerical value only, of the area, is the result desired.

Computations Preparatory to Finding the Area. A survey " closes " if, upon plotting the different courses, the first and last points coincide. If reliance is placed on a graphic construction, it is difficult to tell whether failure to close is due to error in the field or to errors in plotting. For this reason the latitudes and departures of the courses are usually found, and providing a proper set of tables is used, and no mistakes are made in its use, the amount by which the figure fails to close will be the error in field work.

Accordingly, the latitudes and departures of all courses are found. The difference between the plus and minus latitudes will give the error in latitude, and the difference between the plus and minus departures will give the error in departure. The square root of the sum of the squares of these errors will give the amount by which the survey fails to close. This distance divided by the perimeter of the figure will give the " error of closure." If the error of closure be within prescribed limits, the error in latitude and departure may be distributed so as to make the survey close; but if not, the survey, or a part of it, must be repeated.

A suitable form for computing the latitudes and departures

is given in Problem J2. The length of each course is written only once, and the addition of the log of the distance and the log cosine of the bearing is made upward, giving the log of the latitude; the log of the distance and the log sine of the bearing are added downward, giving the log of the departure.

After finding the latitudes and departures, they may be transferred to a table similar to that in Problem J2. The errors may then be distributed according to the proper rule. Finally, the balanced latitudes and departures may be placed either in separate columns or after checking they may be placed in red ink above the unbalanced quantities. In the table given, it is intended that the balanced be placed above the unbalanced quantities.

Rules for Balancing. Three rules may be used for balancing.

Rule 1. *Correct each latitude and departure by the proportion: the correction in latitude* (*or departure*) *of any course is to the total error in latitude* (*or departure*) *as the length of the course is to the perimeter of the field.*

The correction in each case is applied so as to diminish the total error. For example, if the sum of the plus latitudes is greater than the sum of the minus latitudes, the corrections are subtracted from the plus latitudes and added to the minus latitudes. Similar corrections may be applied to the departures.

Where some lines are more difficult to measure than others, the line which was easiest to measure may be given the number 1. Numbers may be given to the others according to their relative ease of measurement, such as 2, $2\frac{1}{2}$, 3, and so on. The length of each course may be multiplied by the proper number, and the sum of the multiplied lengths may also be found. The errors in latitude and departure may then be distributed according to the following rule:

Rule 2. *The correction in latitude* (*or departure*) *of any course is to the total error in latitude* (*or departure*) *as the multiplied length of the course is to the sum of the multiplied lengths.*

Rules 1 and 2 are used where the survey is made by a compass. In this case, both the angles and distances may be in error, and accordingly both should be changed in balancing the survey.

When the survey is made with a transit, and the rule for

angular closure observed, the directions of the courses may be considered exact and the survey should be balanced in such a way that only the lengths of the courses shall be corrected. This is accomplished by the following rule:

Rule 3. *The correction in latitude* (*or departure*) *of any course is to the total error in latitude* (*or departure*) *as the latitude* (*or departure*) *of the course is to the arithmetical sum of the latitudes* (*or departures*).

Computation of the Area. After the survey has been balanced the double meridian distances, D.M.D.'s, are found. The product of the D.M.D. of each course and the latitude of the course should be found, proper attention being paid to the signs of the latitudes. The sum of the products gives the double area of the figure.

The double meridian distances of the courses may be found either by use of a sketch, which is recommended, or in the following way, which it is advised that the student prove to his own satisfaction.

The D.M.D.'s of the two courses adjacent to the reference meridian are equal to their respective departures. The D.M.D. of any other course is equal to the D.M.D. of the preceding course, plus the departure of that course, plus the departure of the course itself; the usual attention being paid to the signs of the departures.

PROBLEM J1. AREA COMPUTATION BY TRIANGULAR SUBDIVISION

Problem. *To compute an area either by taking measurements in the field, so that it is divided into triangles, or by splitting the plot of the area into triangles and scaling all sides.*

Theory. Where the three sides of the triangle are known, the area may be found by the formula

$$A = \sqrt{s\,(s-a)\,(s-b)\,(s-c)},$$

where a, b, and c are the sides and $s = \frac{1}{2}\,(a+b+c)$.

Method and Report. Having secured the information as stated under " Problem " above, find the values of the quantities for substitution in the formula. Logarithms may well be used

for the solutions. The computations and results may be placed in the field note book, both the left- and right-hand pages being used.

PROBLEM J2. AREA BY LATITUDES AND DEPARTURES

Problem. *Having given the bearings and lengths of the sides of a closed figure, to find the area by the latitude and departure method.*

Theory. As previously explained on pages 143 and 144 the double area of a figure is equal to the algebraic sum of the products of the latitude of each course by its double meridian distance.

Method. Sum the angles of the figure and if within limits compute the bearings, starting with a course whose bearing is considered the most reliable. Find the latitudes and departures of the courses, their sum, and the error of closure. If the error of closure is within limits, balance the survey by the proper rule. From the balanced quantities find the double meridian distances (D.M.D.'s) and finally the double areas.

Form of Notes. Make up tables similar to those shown on the two pages following. In this connection three things may be noted.

First, the logarithm of a distance is written but once with the log sine of the bearing above, and the log cosine below it, adding upward the logs of the distance and sine of bearing, for the log of the departure, and adding downward the logs of distance and cosine of bearing, for the log of the latitude.

Second, the balanced latitudes and departures are placed in the table in red ink. In the example given they are in parentheses.

Third, in balancing, note that the quantities in parentheses on the right-hand page are constant and need be found only once each for the latitudes and departures. If logs are used for this work after these constants are found no additional logs need be looked up, the log of each latitude or departure being taken from the table previously computed and added to the log of the constant and the number corresponding to the log of the sum of the two looked up.

Numerical Example. The dimensions of the city block, Problem D3, may be used in this problem, or the data of any survey.

PROB. J2. AREA BY LATITUDES AND DEPARTURES.

Cour-ses.	Bear-ings.	Dist-ances.	Latitudes. N +	Latitudes. S −	Departures. E +	Departures. W −	D.M.D.	Double Areas. +	Double Areas. −
			(181.22)		(60.62)				
E-A	N18°30'E	191.06	181.19		60.62		60.62	10,985.56	
				(39.73)	(449.71)				
A-B	S84°57'E	451.50		39.74	449.75		570.95		22,683.84
				(47.78)	(131.81)				
B-C	S70°04'30"E	140.22		47.79	131.82		1152.47		55,065.02
				(145.19)		(52.78)			
C-D	S19°58'30"W	154.50		145.21		52.78	1231.50		178,801.49
			(51.48)			(589.36)			
D-E	N85°00'30"W	591.55	51.47			589.31	589.36	30,340.25	
		1528.83	232.66	232.74	642.19	642.09		41,325.81	256,550.35
				232.66	642.09				41,325.81
								2	215,224.54

Error of closure $= \frac{\sqrt{.08^2 + .10^2}}{1528.83}$

$= \frac{.128}{1528.83} = \frac{1}{11,950}$

Error in lat. = .08 .10 = Error in dept.

Area = 107,612.27 sq. ft. = 2.470+ acres. 107,612.27

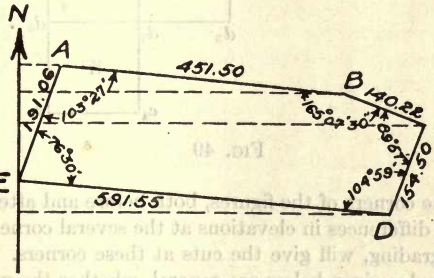
Calculation of Latitudes and Departures.

	EA	AB	BC	CD	DE
dept.	60.62	449.75	131.82	52.78	589.31
log "	1.782646	2.652969	2.119990	1.722458	2.770341
log sin(")	9.501476	9.998311	9.973180	9.533530	9.998349
log dist.	2.281170	2.654658	2.146810	2.188928	2.771992
log cos(lat)	9.976957	8.944606	9.532486	9.973055	8.939573
log "	2.258127	1.599264	1.679296	2.161983	1.711565
lat.	181.19	39.74	47.79	145.21	51.47

Balancing latitudes and departures.

Error in lat. = $\left(\frac{\text{total error in lat.}}{\text{sum of latitudes}}\right)$ lat. of course.

Error in dept. = $\left(\frac{\text{total error in dept.}}{\text{sum of departures}}\right)$ dept. of course



PROBLEM J3. VOLUME OF MATERIAL FROM A BORROW-PIT

Problem. *To compute the volumes for grading a tract of land which has been cross-sectioned.*

Description. The field work for this exercise has been described in Problem E3. The operation there explained is often called " cross-sectioning."

In railroad and other work when the amount of material in embankment exceeds that in cut, the earth is " borrowed " from adjacent tracts. Such tracts are called " borrow-pits."

To compute the amount of material excavated from a borrow-pit, the area is divided into squares or rectangles and elevations

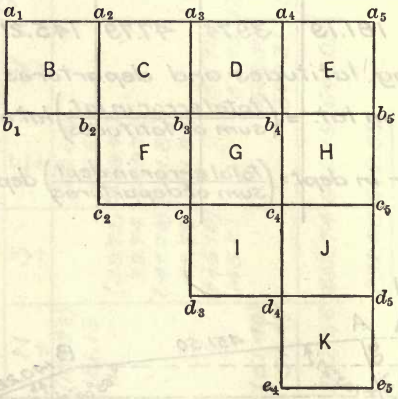


FIG. 49

taken at the corners of the figures, both before and after excavation. The differences in elevations at the several corners, before and after grading, will give the cuts at these corners.

The formulas given below are general, whether the material is in excavation or in embankment.

Each of the regular sections in Fig. 49 is a truncated rectangular prism, whose volume is equal to the average of the four corner

heights multiplied by the area of the right section. That is, the volume of the

$$\text{prism B} = \text{A}\frac{a_1 + a_2 + b_2 + b_1}{4}$$

and of

$$\text{prism C} = \text{A}\frac{a_2 + a_3 + b_3 + b_2}{4}$$

and so on.

It can be seen that with A as a common area, the heights a_1, b_1, c_2, d_3, etc., enter into the volume of one prism only; that a_2, a_3, a_4, etc., enter into two only; b_2, c_3, d_4, etc., into three and so on.

Therefore, if h_1, h_2, h_3, and h_4 represent heights common to one, two, three, and four prisms respectively, the total volume

$$\text{V}_{total} = \text{A}\frac{\Sigma h_1 + 2\,\Sigma h_2 + 3\,\Sigma h_3 + 4\,\Sigma h_4}{4 \times 27} \text{ in cu. yds.}$$

Method. Having decided on the grade elevations of the corners of the squares or rectangles, compare each in turn with the ground elevations. Substitute in the formula above, being careful that the quantities are properly grouped.

CHAPTER XII

PLOTTING

Drawing Instruments. The instruments needed for the ordinary plots of areas and profiles are: A straight edge, two triangles, an engineer's scale, protractors, ruling pen, and lettering pen. Suitable paper should be at hand, also a bottle of red and one of black ink. It is assumed that the student has received elementary instruction in mechanical drawing.

Scale of Drawing. In most engineering offices, drawings are made to certain standard sizes. In this case, the scale to be used for a certain plot will depend largely upon the special size of sheet selected. The final choice of scale may be made by drawing a rough sketch of the tract on a separate piece of paper, and by use of this sketch, place the plot so that it will appear well on the large paper, remembering that there must be a place for the title, an arrow, and any necessary notes of the survey. If the latitudes and departures have been computed, a plotting table may be arranged where the reference meridian passes through the most westerly point of the survey. The latitudes and departures of all points from the two axes will then be given. The proper scale may then be selected and a suitable location on the map obtained from the maximum departures and the sum of the maximum plus and minus latitudes.

Plotting Traverses. There are three common methods of plotting traverses. First, by bearings and distances, making use of a protractor and scale; second, by the natural tangents of angles; third, by latitudes and departures.

Plotting by Bearings and Distances. Select a suitable position for the initial station and for the given meridian. Place the center of the protractor over the first station with the 0° and 180° marks coinciding with the meridian. Lay off the bearings to the two adjacent stations drawing lines in the direction of the stations. Lay off the distances from the first station to the others.

Through the second station draw a line parallel to the original meridian, and by use of the protractor and scale, find the position of the third station. Proceed in this way until the area is traversed. The amount by which the figure fails to close will be the total error of closure. The disadvantage of this method is that we are unable to tell whether this error is due to plotting or to field work.

If either interior or deflection angles are measured, the first line of the survey is laid down, and the proper direction of the second line is found by use of the protractor, the third point being located by the scale. The protractor is then placed at the third station and the forward line located as before.

Natural Tangent Method. The first line of the traverse is plotted, and if the exterior angle at the second station is acute, the line from the first to the second station is prolonged. Ten

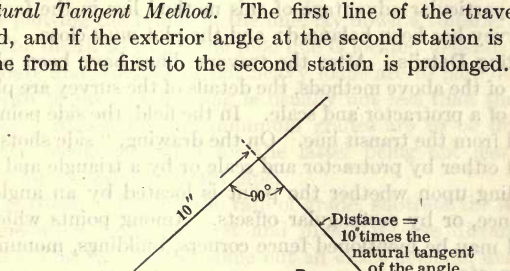


FIG. 50

inches are laid off on this line from the second station, and at this point a perpendicular is drawn. On this perpendicular a length of ten inches times the natural tangent of the exterior angle is laid off and a line joining this point and the second station will give the direction of the second line of the survey. The position of the third station is on this line at the measured distance from the second station. (See Fig. 50.)

If the exterior angle is greater than 90°, the 10″ dimension is either laid off backward along the line between stations, or on a

perpendicular from the given station, and ten times the natural tangent of the proper angle used.

Latitude and Departure Method. The most satisfactory method of plotting a traverse is where the latitudes and departures have been computed and the survey balanced. In this case, the reference meridian and an east and west line may be taken through any station, but preferably through the most westerly or easterly station, and the rectangular coordinates of the points found from this station. A table similar to that given in Problem K3 may be used, and after the points are plotted, they may be joined in succession. A check on the plotting will be secured by measuring the lengths of the different courses.

The particular advantage of this method lies in the fact that the survey has been balanced; and the plot *must* close.

Plotting Details. After the traverse lines have been plotted by one of the above methods, the details of the survey are plotted by use of a protractor and scale. In the field, the side points are located from the transit line. On the drawing, " side shots " are plotted either by protractor and scale or by a triangle and scale, depending upon whether the point is located by an angle and a distance, or by rectangular offsets. Among points which are located may be mentioned fence corners, buildings, monuments, streams, etc.

Profiles. Profiles are usually plotted on special profile paper, although in some cases, as on changes of grade of city streets, they are plotted on the same sheet with the plan of the street. In order to emphasize the changes in elevation, the vertical scale may be exaggerated. The particular scales to be used will depend upon the standard sizes adopted, and to the degree of the exaggeration desired. One of the heavy vertical lines should be taken as station zero, and one of the heavy horizontal lines as some even elevation such as 525, 550, and so on. The rulings on the paper are considered accurate and points are plotted by estimation rather than by use of a scale. After the points are plotted they are connected by free hand straight lines. Points are taken in the field at changes in the slope, so that in plotting the lines should appear approximately straight, but they are *not* to be drawn with a triangle or straight edge. In inking, it is recom-

mended that a ruling-pen or contour-pen be used in preference to a lettering-pen.

Titles. The title to a drawing is preferably placed in the lower right hand corner. For special styles of lettering the student is referred to the different books on this subject.

PROBLEM K1. PLOTTING A PROFILE FOR A DRAIN

Problem. *To plot a profile for a drain, having given the notes.*

Method. A description of the field work of this problem is given in Problem B2. General directions on the plotting of profiles are given in the first part of this chapter, and will not be repeated here.

After plotting the profile of the line, lay down a suitable grade line. The depth to which the pipe line is located depends upon the climate and whether or not heavy loads are to pass over it. The depth to prevent freezing is usually not less than three or four feet. Maximum and minimum grades are to be decided upon, the recommendation for the latter being not less than − 0.2% for an ordinary drain pipe.

Rate of Grade. To find the rate of grade, subtract the second grade elevation from the first and divide by the distance in stations. This rate should come out an exact decimal, and if it does not, some change should be made such as taking the rate an exact amount and changing whichever elevation possible.

PROBLEM K2. PLOTTING A PROFILE OF A STREET

Problem. *To plot the profile of a street from given notes.*

Method. The field work for this problem is given in Chapter III. The method of plotting a street profile is similar to that of plotting any profile, and accordingly the reader is referred to the general remarks on the plotting of profiles on page 154.

For the proper understanding of a profile it should be accompanied by a plan of the street. It is also desirable to show the points where the lines of intersecting streets cut the center line of the given street.

PROBLEM K3. PLOTTING A CITY BLOCK

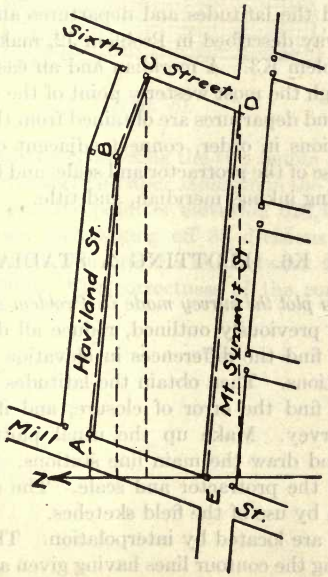
Problem. *To make the map of a city block from given notes.*

Method. Having found the latitudes and departures, and balanced the survey as in Problem J2, make up a plotting table similar to that in the accompanying illustration. A meridian and an east and west line are drawn through the most westerly point of the survey and the *total latitudes* and *departures* of each point found with respect to this point. Lay off the coordinates in the proper direction and draw lines connecting the successive stations. Then, by use of a protractor and scale locate the side streets and other monuments, taking each transit station in order. Finally complete the work by lettering the streets, inking, making a suitable border line, a meridian and a title.

PROB. K3. PLOTTING A CITY BLOCK

PLOTTING TABLE.

Point.	Latitude.	Departure.
E	0.00	0.00
A	+181.22	+ 60.62
B	+141.49	+510.33
C	+ 93.71	+642.14
D	- 51.48	+589.56



PROBLEM K4. PLOT OF A BORROW-PIT

Problem. *To make the plot of a borrow-pit.*

Method. Make a drawing similar to that shown in Fig. 49. Place the elevations of the points at each corner, reading diagonally. Considering that the ground slopes uniformly from one corner to another, interpolate for the contours required. After the contours are located, the volumes for grading may be found if so desired, by use of the planimeter.

PROBLEM K5. PLOTTING A LARGE AREA

Problem. *To plot the survey made in Problems M1 or M2.*

Method. The method of latitudes and departures is recommended for plotting the main line of this survey, and a protractor and scale for the side shots.

Having found the latitudes and departures and balanced the survey in the way described in Problem J2, make up a plotting table as in Problem K3. A meridian and an east and west line are taken through the most westerly point of the survey, and the total latitudes and departures are obtained from this point. Plot the transit stations in order, connect adjacent ones, locate the side points by use of the protractor and scale, and finally complete the map including inking, meridian, and title.

PROBLEM K6. PLOTTING A STADIA SURVEY

Problem. *To plot the survey made in Problem M3.*

Method. As previously outlined, reduce all distances to the horizontal, and find the differences in elevation of the stations and their elevations. Then obtain the latitudes and departures of the courses, find the error of closure, and if within limits, balance the survey. Make up the usual plotting table (see Problem K3) and draw the main line stations. Locate all side shots by use of the protractor and scale. The special features are to be drawn by use of the field sketches.

The contours are located by interpolation. There are several ways of obtaining the contour lines having given a series of points

with their elevations. One method quite commonly employed is shown by Fig. 51.

The difference in elevation in tenths between the two points is 72 and the 520.0 contour is desired. Similar triangles are con-

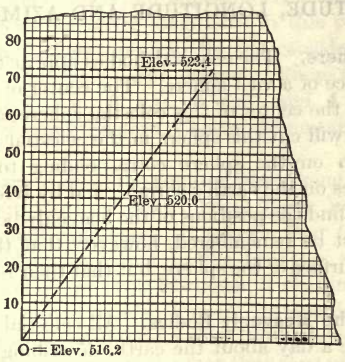


FIG. 51

structed graphically by connecting the two points by a line. By using a piece of cross-section paper as shown in the sketch, so that a perpendicular from the point of elevation 523.4 will intercept 72 parts on it, and then taking off 38 divisions on the scale. Where the 38-division line cuts the line between the points, will give elevation 520.0. The correctness of the construction can be easily seen.

CHAPTER XIII

LATITUDE, LONGITUDE AND AZIMUTH

Celestial Sphere. The celestial bodies appear to be points on the inner surface of a vast sphere. The center of the earth may be regarded as the center of this celestial sphere, and the earth's axis prolonged will cut this sphere in the celestial poles. Circles may be drawn on the sphere corresponding to latitude and longitude circles on the earth's surface, and by reference to these circles we may find the positions of the heavenly bodies at certain times. It must be remembered, however, that these bodies do not lie on the surface of the sphere, but that their *relative positions* only, are seen.

Motions of the Heavenly Bodies. All celestial bodies appear to revolve once a day about the earth, describing circles on the celestial sphere. The apparent motion, both daily and annual, of the fixed stars are in circles parallel to the celestial equator. The *apparent daily motion* of the sun is also very nearly parallel to the equator. The sun's *apparent yearly motion* is an ellipse and inclined to the plane of the equator by an approximately constant angle of 23° 27′.

Coordinates. The angular distance a body is above or below the equator, is its *declination*. This distance is measured on a circle passing through the poles. When north of the equator it is considered *plus*, and when south of the equator, *minus*. The *altitude* of a body is its distance above or below the horizon, and it is measured on a circle passing through the zenith. As respects the sun, it is measured from the south clockwise, as in ordinary surveying, but as applied to the circumpolar stars, it is east or west of north. In the celestial sphere it is the angle at Z between the plane of the meridian and a circle passing through the zenith and the body. This circle is perpendicular to the horizon.

Declination. As previously stated, the declination is the angular distance of a body above or below the equator. The

declination of the sun and other bodies may be found from "The American Ephemeris and Nautical Almanac." The values are given, however, for either the Greenwich or Washington meridians. The declination for Polaris is given for Washington, and since it changes very slowly, no apparent error will arise if it is considered constant for other longitudes in this country. The sun's declination changes more rapidly and consideration should be paid to the time belt. For example, when it is noon at Greenwich, it is 7 A.M., 6 A.M., 5 A.M., and 4 A.M., respectively at places keeping Eastern, Central, Mountain, and Pacific times.

The sun appears to cross the equator when going northward in March, and southward in September. These points are the *vernal* and *autumnal* equinoxes. It takes a year for the sun to apparently complete its circuit in the heavens, and since the angular inclination of the orbit is known, if the time or position of the sun in its circuit is also known, its angular inclination above the equator (or declination) may be computed.

Refraction. On account of the fact that rays of light coming to the earth from exterior bodies are refracted downward, such bodies appear higher than they really are. The value of the refraction is zero for points immediately above a person and increases toward the horizon.

When the altitude of a body is measured, the refraction correction as found in Table IV is substituted. In using the solar attachment, the refraction is added since we have the theoretic quantities, and wish to find the position of the real sun. The size of the correction depends upon the sun's hour angle, and the latitude of the place, and is given in Table VI. An example of its application will be found in Problem L3.

Positions of Bodies for Observations. When a body is on a meridian its altitude is either a maximum or a minimum. Such a position of a body is called a *culmination.* (Commonly called *transit* for the sun.) When at its extreme eastern or western position it is at an *elongation.*

It may easily be proved that *the altitude of the celestial pole is equal to the latitude of the observer.* If a star were located at the north pole, the latitude of the place would be the measured

altitude of this star, corrected for refraction. As there is no such star, other bodies very near the pole are used for observations. The one generally used by the civil engineer is Polaris, called the North Star. A body is moving *very slowly in altitude* when nearing culmination and this position will give the best determination for latitude. On the contrary, when at elongation, the motion is rapid in altitude, but very slow in azimuth, and this position will be best for a determination of true north or azimuth.

Problems will be given in this chapter for determinations of latitude by observations both on Polaris when at culmination, and the sun when on the meridian; and for azimuth, on Polaris when at elongation, and at any hour.

Inasmuch as it often proves inconvenient to await the time until a body comes to culmination or elongation, observations are taken at some intervening time. Common observations are: Azimuth by observation on Polaris at any time; azimuth by observation on the sun when off the meridian, either directly or by use of the solar attachment. In these cases, it is best not to observe when the body is too near the horizon since the refraction correction is unduly large.

Longitude. The *longitude* of a place is its distance east or west from a reference meridian. The reference meridian used is that of Greenwich. The measurement of the difference in longitude of two places, depends upon the comparison of the local times of the places at a certain instant of time. Longitude might be determined by carrying a timepiece from one station to another and noting the time of passage of a body over each meridian. The difference in time, provided the watch is properly regulated, would give the difference in longitude in hours. Another method is by telegraphing the time of the meridian passage from one station to another. The method commonly used by the civil engineer is to observe the sun at equal altitudes, east and west of the meridian, noting the times. The mean of the two times will give the standard time of local apparent noon. This may be reduced to local mean noon and compared with Western Union time. If the watch is correct, the difference between the local mean time of meridian passage and standard noon, will give the difference

between the local and the standard meridians or the difference in longitude in hours. Due to the changing declination of the sun, a slight correction must be applied and this is given in Problem L5.

Time of Culmination or Elongation. If there is no concern for waste of time, observations may be made by following the motion of a body until it reaches either of these extreme positions. The explanation of the methods of *computing* the times at which bodies culminate or elongate is given in treatises on practical astronomy, and is beyond the province of this book. Tables have been prepared for giving these and some of them will be explained in the problems where this information is needed.

Instruments Used for Observing. One of the following combinations is generally used for the problems in this chapter: An engineer's transit with full vertical circle, prismatic eyepiece, and reflector for illuminating the cross-wires; an engineer's transit with some form of solar attachment; or a sextant with an artificial horizon.

Order of Problems. Since the determination of azimuth will probably be more often encountered by the readers of this book, the order of problems in this chapter will be the reverse of that in the title.

PROBLEM L1. AZIMUTH BY OBSERVING POLARIS AT ELONGATION

Equipment. Engineer's transit with reflector, small lantern for illuminating the cross-wires, plumb-bob (with some method of making it visible), or a wooden box with a vertical slit cut in it, and an ordinary lantern.

Theory. Polaris appears to revolve around the north pole once in approximately 23 hours and 56 minutes. When it is at elongation, the angle Z in Fig. 52, must be taken into account. The value of Z is found by use of Table X.

Method. About 20 minutes before the time of elongation, set up the transit over one point in the line whose azimuth is to be determined. Level the instrument carefully. Set vernier A at zero, and slightly *before* the time of elongation, sight at the other point in the line. Unclamp the upper motion and sight at the

star, read the vernier and note the time. At about the same time *after* elongation again read the vernier. Take the mean of the two readings. Apply the value of Z in the right triangle to

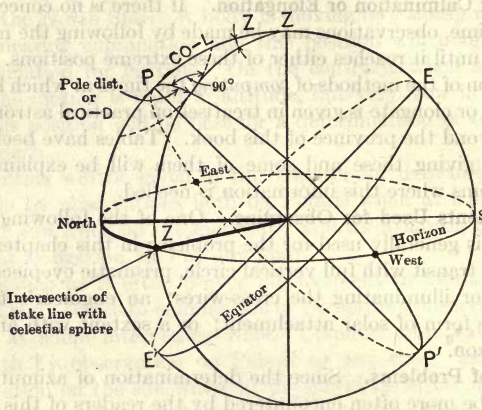


FIG. 52

this mean reading, and obtain the azimuth of the line referred to north.

Time of Elongation. A numerical example will be taken to illustrate the use of Table IX. Suppose that the time of elongation of Polaris is required after mean noon of Feb. 18, 1916, at 42° North Latitude and 82° West Longitude.

The western elongation on Feb. 15, 1915, occurs at 9 h. 44.4 m. P.M. at 40° latitude and 90° longitude. Corrections are applied as follows: (See directions given with Table IX, A, B, C, D and E.)

From A	For 1916 up to March 1	= + 1.6 m.
" B	For 3 days after the fifteenth	= − 11.8 "
" C	For 82° Longitude instead of 90°	= − 32.0 "
" D	For 42° Latitude instead of 40°	= − 0.32 "
" E	For 82° Longitude instead of 90°	= + 0.07 "
Total correction		= − 42.45 m.

Applying this correction to 9h. 44.4 m. it gives approximately 9h 01 m. P.M. as the time of the western elongation of Polaris on Feb. 18, 1916, at 42° north latitude and 82° west longitude.

Azimuth of Polaris at Elongation. With data as in the preceding paragraph, the azimuth of Polaris can be found by use of Table X.

The azimuth of Polaris in 1916 for latitude 42° is	1° 32′.3
The correction for the middle of February is	− 0′.4
The azimuth on Feb. 18 is, accordingly,	1° 31′.9

Conclusion. Polaris at its western elongation is 1° 31′.9 to the west of North. Apply this value properly to the angle between Polaris and the given line, in order to find the azimuth of the line.

After taking the sight on Polaris at elongation, the telescope may be depressed and a stake located some two hundred feet or more from the instrument. At daylight, the angle Z may be laid off in the proper direction from this line and the line so located will be in the true meridian.

PROBLEM L2. AZIMUTH BY DIRECT SOLAR OBSERVATION

Equipment. Engineer's transit with full vertical circle, prismatic eyepiece with colored glass, and solar ephemeris.

Theory. For a solution of this problem it is necessary to know either the three sides of the spherical triangle SPZ in Fig. 53, or two sides, SP and ZP, and the hour-angle or apparent time, which is the angle at P. In the solution of the first case,

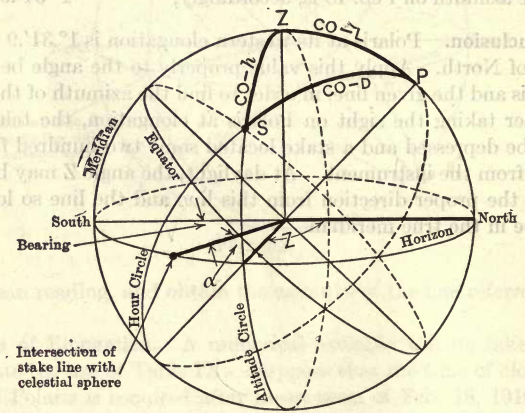


FIG. 53

the three sides are obtained in the following manner: The side ZP is equal to the co-latitude, the latitude being taken from a map or being obtained from observation on Polaris at upper or lower culmination. The side SP is equal to the co-declination, which is obtained by use of the solar ephemeris, knowing the time. The side ZS is equal to the co-altitude, and is obtained by measuring the altitude and correcting for refraction, index error, etc. In the second case, the sides ZP and SP are known and the angle ZPS. The side ZS can be found and also the angle Z. Knowing the angle Z, the azimuth of the sun can be found, being

$180° \pm Z$. The first method, being the more general one, is given.

Method. Set up the transit over one end of the line whose azimuth is desired. Level up with extreme care, using the telescope bubble, and if the vernier of the vertical circle does not have an attached bubble, note the index error. Set vernier *A* at zero and sight on the hub at the other end of the line. Unclamp the upper motion, turn the telescope to the sun and bring the sun's image into the quadrant so that it appears to run onto both wires. Note the time to the nearest minute, and read the vertical and horizontal circles. Invert the telescope and bring the sun's image into the quadrant, where it seems to recede from both wires. Note the time, and read the vertical and horizontal circles.

Time of making observation. To secure reliable results, the observation must be made when the sun is between two and four hours from the meridian.

Modification. If unable to get a pair of observations on account of the sun being obscured, one observation is used. In this case, the altitude is corrected for the sun's semi-diameter before the reductions are made, and the computed azimuth is then corrected by the quantity $\frac{\text{sun's semi-diameter}}{\text{cos. altitude}}$. If the instrument does not have a complete vertical circle, this method *must* be used.

Calculations. Find the mean altitude and the mean plate-reading. Correct the apparent altitude for refraction (see Table IV). Knowing the time, the declination is found as follows: The sun's apparent declination and its hourly change for Greenwich mean noon are given in the Nautical Almanac. For any other place it may be obtained, if the longitude of the place and the mean time are known.

For example, the difference of time between Greenwich and Philadelphia is five hours. Therefore, the declination for two o'clock at Philadelphia is equal to the declination for Greenwich mean noon on the day in question, plus 7 times the hourly change (if the declination is increasing). If the observations are made when the sun is from two to four hours from the me-

FORM OF

Telescope.	Time.	Hor. circle.	Vert. circle.	Refraction.
Direct	9.29	228° 37′ 20″	52° 14′ 00″	.....
Reversed	9.31	230° 8′ 40″	53° 17′ 00″	.....
Mean	9.30	229° 23′ 00″	52° 45′ 30″	−0′ 44″
Direct	9.38	230° 38′ 00″	53° 44′ 40″	.....
Reversed	9.40	232° 10′ 00″	54° 42′ 50″	.....
Mean	9.39	232° 24′ 00″	54° 13′ 45″	−0′ 42″

Also give on the right-hand page brief computations for the solution of the spherical triangle.

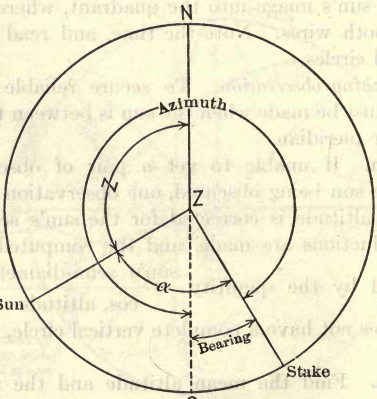


FIG. 54

ridian, the error caused by the difference between mean local time and standard time will be inappreciable, when an engineer's transit reading only to minutes is used.

Then, having the altitude, the declination, and the latitude, the co-functions may be found, and finally the angle at Z, by use of the formula $\sin^2 \frac{1}{2} Z = \dfrac{\sin (s - \text{co-}h) \sin (s - \text{co-}L)}{\sin \text{co-}h \sin \text{co-}L}$, where h = the true altitude, L = the latitude, and $s = \frac{1}{2}$ (co-h + co-L + co-D).

NOTES

h.	*D.*	*Z.*	True azimuth.	Transit *T* fifteen used.
.....	.....	.....	.....	
52° 44′ 46″	+23° 15′ 18″	106° 55′ 22″	57° 32′ 22″	
.....	.....	.....	.....	
54° 13′ 03″	+23° 15′ 19″	108° 55′ 52″	57° 31′ 52″	*L*=41° 27′

Finally, the azimuth of the line may be found by use of the angle α. This angle is the angle between the stake and the sun, and is measured to the right, starting from the stake. It is the angle recorded in the " horizontal circle " column in the notes below, provided that zero was first set on the stake.

Fig. 54 shows one position of the reference-line and sun. A general equation might be deduced connecting the azimuth with the quantities α and Z, but it is best to construct a figure for each problem as it arises. The data in the notes below do not conform to the above figure.

PROBLEM L3. DETERMINATION OF AZIMUTH BY USE OF THE SOLAR ATTACHMENT.

Equipment. Transit with solar attachment and the solar ephemeris, and a table of declinations and refraction corrections computed for a series of observations varying in time from 3 to 10 minutes, depending upon the skill of the observer.

Method. Set up the transit over one point of the line whose azimuth is to be determined. Level up carefully, using the long telescope bubble. Set vernier *A* of the horizontal plate at zero, and sight at the second point in the line with the upper motion clamped. Unclamp the upper motion, and having laid off the sun's apparent declination on the declination arc, and the co-latitude on the vertical circle, turn the alidade in azimuth and the attachment about its polar axis until the sun's image appears between the lines of the silver disk. The telescope will then point south, and the azimuth of the mark may be read on the plates. This applies to the Burt attachment.

If the Saegmuller attachment is used, the vertical circle of the main telescope must be used in laying off the declination. The co-latitude is laid off as with the Burt attachment (not from the declination reading). In the final setting of the instrument, the angle between the lines of sight of the small and the large telescope is equal to the apparent declination, and the main telescope is in the plane of the equator, the object end pointing south. After taking a series of six readings with the instrument in this position, turn the alidade 180° and set off the co-latitude as before. The eyepiece end is now pointing south. Take a series of six readings as before. The mean of the twelve readings will be the true azimuth of the line, the instrumental errors having been eliminated by the reversal.

Fig. 55 shows the position of the Burt attachment on a transit and its relation to the celestial sphere.

Computations. The declination is obtained in a manner similar to that given in the preceding problem. The apparent declination is found by applying the refraction correction obtained from Table VI. When using the attachment, the refraction correction is a function of the latitude of the place, the horizontal angle, and the declination.

FORM OF NOTES

Time.	Inst.	Decl.	Refr. corr.	App. decl.	Azimuth.	Mean azim.
2.55	Direct	21° 43′	+0′ 33″	21° 44′	18° 51′	.....
.....	Direct	.....	.....	.....	.....	.....
.....	Direct	.....	.....	.....	.....	.....
3.27	Direct	21° 43′	+0′ 47″	21° 44′	18° 50′	18° 50′ 30″
3.41	Reversed	21° 43′	+0′ 47″	21° 44′	161° 11′	.....
.....	Reversed	.....	.....	.....	.....	.....
.....	Reversed	.....	.....	.....	.....	.....
3.51	Reversed	21° 43′	+0′ 47″	21° 44′	161° 12′ 20″	161° 11′ 30″

Date, party, equipment as usual.
$L = 41° 27'$.
co-$L = 48° 33'$.
Index error 0° 20′.
Give calculations for declination.
Mean azimuth = 18° 49′ 30″.

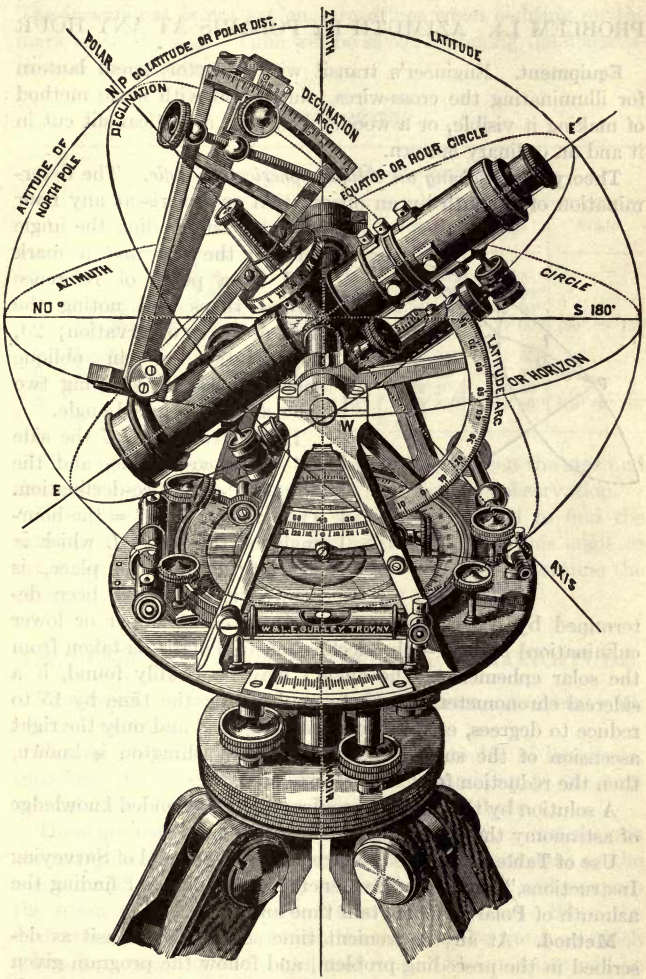


FIG. 55. — Graphic Illustration of the Solar Apparatus

PROBLEM L4. AZIMUTH BY POLARIS AT ANY HOUR

Equipment. Engineer's transit with reflector, small lantern for illuminating the cross-wires, plumb-bob with some method of making it visible, or a wooden box with a vertical slit cut in it and an ordinary lantern.

Theory. *By solving an oblique spherical triangle.* The determination of azimuth by an observation on Polaris at any hour involves, 1st, reading the angle between the star and a mark used as a point of reference several times and noting the time of each observation; 2d, the solution of an oblique spherical triangle knowing two sides and an included angle.

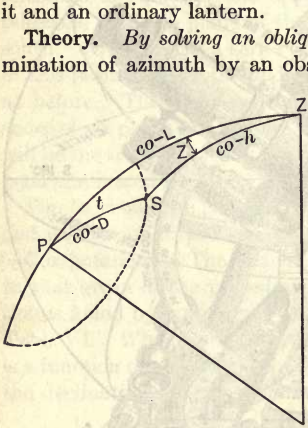


FIG. 56

In the triangle SPZ the side PZ = the co-latitude, and the side PS = the co-declination. The angle at $P = t$ = the hour-angle of the star. L which = the latitude of the place, is known (it may have been determined by observation on Polaris at either upper or lower culmination) and D = the declination of Polaris, is taken from the solar ephemeris. The angle t may be readily found, if a sidereal chronometer is used, by multiplying the time by 15 to reduce to degrees, etc., but if a watch is used and only the right ascension of the sun at mean noon in Washington is known, then the reduction for t is more extended.

A solution by this method requires a more extended knowledge of astronomy than is here given.

Use of Tables. Tables are given in the "Manual of Surveying Instructions," issued by the General Land Office for finding the azimuth of Polaris at a certain time and place.

Method. At any convenient time set up the transit as described in the preceding problem, and follow the program given below. Throughout the observation the lower motion is clamped.

The instrument is not set on zero either when sighting on the mark or on the star. Time will be saved by taking the observations in the order given.

FORM OF NOTES

Inst.	Time.	Sight.	Horizontal angle readings.			
			Ver. A.	Ver. B.	Mean.	Angle.
R	.....	Mark	125° 30′ 30″	−30′ 30″	−30′ 30″	.....
D	.....	Mark	125° 30′ 00″	−30′ 00″	−30′ 00″	.....
D	9 h. 34 m. 05 s.	Star	225° 40′ 00″	−40′ 00″	−40′ 00″	.....
D	9 h. 35 m. 00 s.	Star	225° 39′ 00″	−39′ 00″	−39′ 00″	100° 09′ 15″
R	9 h. 52 m. 44 s.	Star	225° 38′ 00″	−38′ 00″	−38′ 00″	.....
R	9 h. 54 m. 00 s.	Star	225° 37′ 30″	−37′ 30″	−37′ 30″	.....
R	.....	Mark	125° 29′ 30″	−29′ 30″	−29′ 30″	.....
D	.....	Mark	125° 29′ 30″	−29′ 30″	−29′ 30″	100° 08′ 15″

Find from these notes the average angle between the star and the mark; also the average of the four times of observation.

From the table in the book previously referred to find the azimuth of Polaris at the computed time. Apply this angle to the angle between the star and the line and thus determine the azimuth of the line.

PROBLEM L5. DETERMINATION OF LONGITUDE

Equipment. Transit with prismatic eyepiece, or sextant with artificial horizon.

Theory. One hour in time is equivalent to 15° of longitude, therefore, the difference in time from one meridian to the next multiplied by 15 will give the difference in longitude.

There are many ways of determining longitude, — but the one ordinarily used by the civil engineer is to observe a star or the sun at equal altitudes east and west of the meridian, and compare the mean of the times with Western Union time. Since the declination of a star is constant, the mean of the times at which a star is at equal altitudes east and west of the meridian will be the time of meridian passage in hours. As the sun's declination

changes slightly, a correction must be applied to the mean of the times when the sun is observed. The equation is

$$\mp e = \frac{-t\Delta}{15}\left(\frac{\tan L \tan D}{\sin t \tan t}\right)$$

where t = one-half the interval in hours between the two observations; L = the latitude of the place; D = the sun's declination; and Δ = the hourly change in declination.

Use $-$ sign before e if declination is increasing, and $+$ if decreasing.

Method. Observe the body when it is about 2 to 3 hours to the east of the meridian, note carefully the watch time, and measure the altitude. Observe again when it reaches the same altitude (at the west of the meridian) and note the time. During the intervening interval, compare the watch with Western Union time and note its error.

Computations. Correct the time piece for its error. Apply the correction equation to the time of the sun's meridian passage, and this will give the watch time of apparent noon. Apply the equation of time (found in the American Ephemeris) to the time of apparent noon, and obtain the watch time of local mean noon. This compared with Western Union time will give the difference in hours between the local and the standard meridians.

PROBLEM L6. LATITUDE BY OBSERVING POLARIS AT CULMINATION

Equipment. Transit with reflector, and watch which has the correct standard time.

Theory. See Problem L1, and the text of this chapter.

Method. Having computed the time of culmination, set up the transit about ten minutes before this time, and bisect the star, reading the vertical circle. Invert the telescope, correct the plate-levels if necessary, and again sight at the star about the same time after culmination. Take the mean of the two vernier readings. This value, corrected for refraction and for the pole distance of the star, will give the latitude of the place.

Time of Culmination. The solar time between an *upper* culmination and an elongation is ± 5 h. 55 m., and that between a *lower* culmination and an elongation is ± 6 h. 3 m. Find the time of elongation as in Problem L1 and apply the proper time interval to it to obtain the time of culmination.

Numerical Example. Taking the same data as in Problem L1. The time of western elongation was found to be 9 h. 01 m. P.M. The time of the preceding culmination (lower culmination) was 6 h. 03 m. earlier, viz., 2 h. 58 m. P.M. The star was invisible at that time, therefore, take the culmination (upper) 5 h. 55 m. later or at 2 h. 56 m. A.M.

Another way to compute the time of culmination is by taking the time from Table IX and applying corrections as there noted.

PROBLEM L7. DETERMINATION OF LATITUDE WHEN THE SUN IS ON THE MERIDIAN

Equipment. Transit with colored eyepiece and colored glass.

Theory. The local apparent time of the sun's transit is 12 M. The mean solar time, however, which is the time according to the motion of a fictitious sun, is different from the apparent time. Therefore, a correction, called the equation of time, has to be applied to the apparent time to give the mean solar time of the sun's transit. But clock time is standard time, and standard time varies from 0 to 30 minutes from the mean solar time. Therefore, find the difference of longitude in degrees between the place of observation and the standard meridian (for which the time of the place is correct). Divide by 15, and apply this correction to the mean local time to get the standard or clock time of transit. Then, knowing the standard time of the sun's transit, the instrument may be set up shortly before this time and the altitude of the sun determined. This altitude corrected for refraction, index error, and semi-diameter gives the true altitude of the sun's center. Then 90° − altitude = the zenith distance, and the zenith distance ± sun's declination = latitude of the place.

Method. Level the transit carefully by use of the long telescope bubble, and point at the sun so that the sun's image ap-

proaches the horizontal wire. Follow the sun until the watch (which has been set with a standard timepiece) registers within 2 or 3 minutes of the time of culmination. Make the cross-wire tangent and read the circle. Reverse the telescope and relevel the instrument. Again point on the sun. Make the horizontal wire tangent and read the circle. Both readings should be taken as near the clock time of culmination as possible, and in no case more than five minutes from this time.

Note. If a sextant and artificial horizon are used, the double altitude of the sun is obtained. The observation is made as near the exact time of culmination as possible. The index error should be applied to the measured angle, and the corrections for refraction and semi-diameter applied.

The above method gives a fair value of the latitude and may be used by the engineer in the field without tedious reductions for circummeridian altitudes. If a more exact value is needed, a treatise on astronomy should be consulted.

The notes appended were taken without regard to the mean local time of the sun's transit. The instrument was set up over one end of a line whose azimuth had been determined. The telescope was then pointed to the meridian, and the altitude of the lower limb of the sun determined to the nearest 20 seconds as it passed the vertical wire. The corrections were then applied and the latitude found.

OBSERVATION FOR LATITUDE

Apparent altitude	69° 42′ 20″	
Index correction	+ 0° 20′	Index error = 0° 20′.
Sun's semi-diameter	+ 15′ 51″	
Refraction correction	− 0′ 24″	$L = 90° - (h + I + \text{semi-dia.} - r - D)$.
Declination	21° 42′ 25″	
co-L	48° 35′ 22″	
L	41° 24′ 38″	

CHAPTER XIV

LARGE SURVEYS

The instruments and methods to be used in making a certain survey will depend largely upon the value of the land and the particular object of the survey. If it is a question of the location of the lines between tracts owned by different parties, more care must be taken than is ordinarily the case. No absolute statement can be made as to the particular method which is best for any survey. Descriptions of the methods of making three different classes of surveys are given in the problems of this chapter. It is believed that from the suggestions given, modifications can be made to suit the particular need.

PROBLEM M1. FARM SURVEY

Equipment. Transit, two range poles, steel and cloth tapes, set of marking pins, hatchet, stakes and tacks.

Problem. *To make the survey of a farm. Assumed that the corners of the farm are known, and that the area and a plot are desired.*

Method. Place two stakes on or along a boundary line so that they are intervisible. Set up over the second stake and find the magnetic bearing of the line and its length. Assume (provided no special objection exists), that this bearing is correct. Set a forward stake at or near another corner of the field. Measure the angle (either deflection or interior as previously decided) to the forward point and compute the bearing of the line between the stations. Observe the magnetic bearing of the line as a check on the computed bearing. Measure the distance between the successive stations. At each station take angles and distances to property corners and to other points desired, such as buildings, etc.

As shown in the accompanying illustration, the transit line is sometimes run inside the property line and again outside. If

thought advisable, buildings may be located as there shown by a plus along the transit line, and an offset from this line.

The accuracy of the work depends upon the care taken in chaining and in measuring the angles, provided the instrument is carefully set up, centered, and leveled. In this connection, the following points may be observed. A check on the angular work may be had by doubling all important angles, always reading the first angle before doubling. The measurement obtained by chaining may be checked by finding the intercept on a range pole or a stadia rod. In case the boundary line is irregular, offsets from the transit line are taken at frequent intervals. These offsets are taken at right angles to the transit line, the interval between successive offsets depending upon the regularity of the boundary-line in question. A cloth tape is used in measuring these offsets.

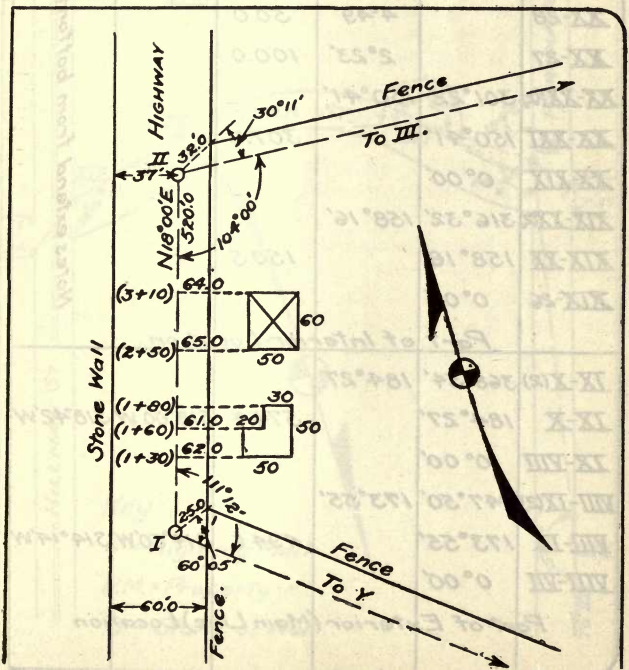
Property Survey. If it is possible to run the traverse line on the boundary-lines themselves, the bearings and lengths of courses will be given directly, If, however, the traverse line does not form the boundary-line of the farm, then the description can be written only after the traverse is balanced, and the line computed by trigonometric methods. In all cases enough data must be taken to give a solution.

Computations. Compute the latitudes and departures as described in Problem J2. Find the error of closure. Balance the survey according to the proper rule, and find the corrected bearings and lengths of the courses. Finally, find the double meridian distances and the double area.

Notes. Notes may be a combination of tabular form and sketch. See accompanying form for illustration.

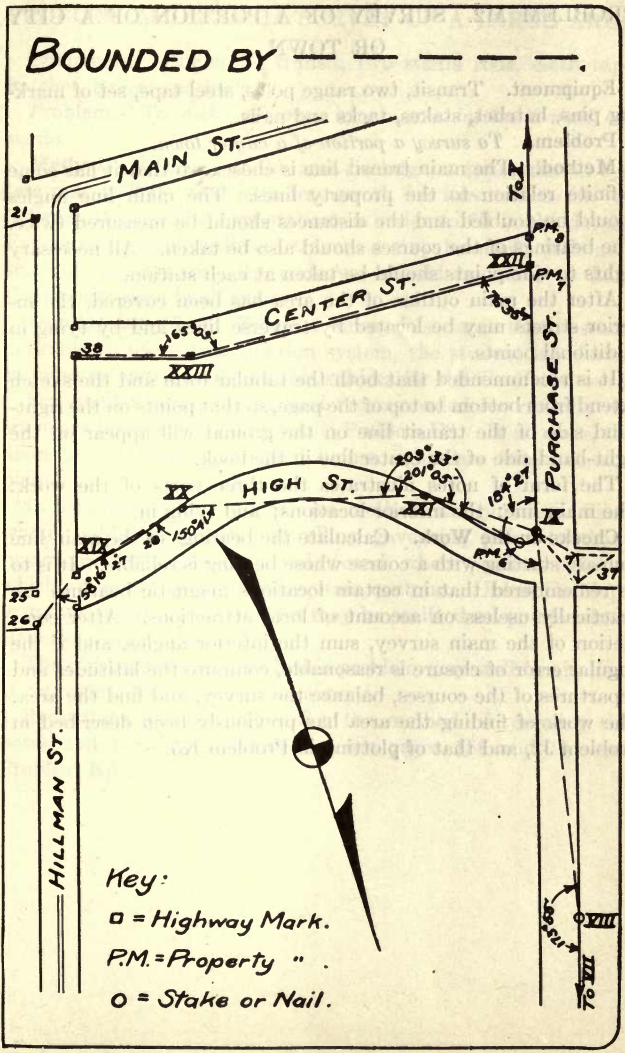
PROB. M I. FARM SURVEY.

Line.	Ver. R'd'g.	Angle	Dist.	Mag. Bear.	Calc. Bear.
I-1		60°05'	25.0'	And so on.	
I-II(2)	222°24'	111°12'	520.0'	N18°00'E	N18°00'E
I-II	111°12'				
I-Y	0°00'	Notes To read from bottom up.			



PROB. M2. SURVEY OF AREA

Line.	Ver. Read.	Angle.	Dist.	Mag. Bear.	Calc. Bear.
7-37			75.0	And so on.	
6-37			87.8		
6-7			46.0		
IX-7			65.2		
IX-6			101.0		
		Tieing in.			Notes extend from bottom to top.
XX-28		4°49′	50.0		
XX-27		2°23′	100.0		
XX-XXI(2)	301°22′	150°41′			
XX-XXI	150°41′		307.8		
XX-XIX	0°00′				
XIX-XX(2)	316°32′	158°16′			
XIX-XX	158°16′		159.5		
XIX-26	0°00′				
	Part of Interior Location.				
IX-X(2)	368°54′	184°27′			
IX-X	184°27′		574.4	S19°00′W	S18°42′W
IX-VIII	0°00′				
VIII-IX(2)	347°50′	173°55′			
VIII-IX	173°55′		494.6	S14°50′W	S14°14′W
VIII-VII	0°00′				
	Part of Exterior (Main Line) Location				


BOUNDED BY — — — — —.
MAIN ST.
CENTER ST.
HIGH ST.
PURCHASE ST.
HILLMAN ST.
To I
To XII
21
38
XXIII
XXII
P.M. 8
P.M. 7
XX
XXI
XIX
IX
XVIII
P.M. 6
25
26
37
Key:
□ = Highway Mark.
P.M. = Property " .
O = Stake or Nail.

PROBLEM M2. SURVEY OF A PORTION OF A CITY OR TOWN

Equipment. Transit, two range poles, steel tape, set of marking pins, hatchet, stakes, tacks and nails.

Problem. *To survey a portion of a city or town.*

Method. The main transit line is chosen, so that it has some definite relation to the property lines. The main line angles should be doubled and the distances should be measured twice. The bearings of the courses should also be taken. All necessary sights to side points should be taken at each station.

After the main outline of the area has been covered, the interior streets may be located by traverse lines and by tying in additional points.

It is recommended that both the tabular form and the sketch extend from bottom to top of the page, so that points on the right-hand side of the transit line on the ground will appear on the right-hand side of the center line in the book.

The form of notes illustrates the three parts of the work: The main line; the interior locations; and tying in.

Checks on the Work. Calculate the bearings of the main line courses, starting with a course whose bearing is reliable. It is to be remembered that in certain locations magnetic bearings are practically useless on account of local attractions. After completion of the main survey, sum the interior angles, and if the angular error of closure is reasonable, compute the latitudes and departures of the courses, balance the survey, and find the area. The work of finding the area has previously been described in Problem J2, and that of plotting in Problem K5.

PROBLEM M3. STADIA SURVEY OF A LARGE AREA

Equipment. Engineer's transit, two stadia rods, cloth tape, hatchet, stakes and nails.

Problem. *To make a survey of an area by the transit and stadia.*

Method. *General.* If the area be large, a triangulation system may well be used as a framework for traverses to be run between the triangulation stations in order to fill in the details. For smaller areas, ordinary traverses may be used, without a triangulation system. An endeavor should be made to have the circuits close in all cases.

Detailed Directions. Where a survey is so large that it seems desirable to use a triangulation system, the student is referred to more extended books on this subject for details of the work.

For smaller areas, the method recommended for running the traverses is similar to that given in Problem E2. In all cases, the main line stations are located before sights are taken at side points.

In locating contour points, two methods are pursued: First, where sights are taken controlling governing points without regard to their elevations; and second, where points are taken which are approximately in a certain contour. Unless the slope is unduly steep, vertical angles may be omitted on points whose elevations are not wanted.

The illustration given with this problem may well be studied. It represents part of an actual survey.

Reductions and Plotting. For the method of reducing the notes and locating the contours, see pages 158 and 159 and Problem K6.

PROB. M3. STADIA SURVEY

Inst. at	Sight at	Azimuth	Obs. Dist.	Vert. Ang.	Mag. Bear.
	etc.				
	87	352°35′	.77		
	86	352°35′	1.29		
	—				
	68	144°32′	1.05		
	67	144°05′	.47		
	R	358°15′	3.65	+0°20′	S 2°00′E
(495.83) Q	P	227°26′	3.99	+0°16′	N47°45′E
	etc.				
	57	26°28′	3.70		
	56	95°22′	1.80		
	55	335°03′	2.30		
	54	23°35′	2.65		
	53	57°00′	1.27		
	52	350°35′	1.63		
	Q	47°26′	3.99	−0°16′	S47°30′W
(497.72) P	O	155°39′	3.20	0°00′	N25°00′W
	etc.				
	48	333°53′	2.37		
	47	348°55′	2.30		
	—				
O	—				

Ground practically level. Only main line elevs. taken.

OF			Remarks or Sketches:
Hor. Dist.	Diff. Elev.	Elev.	
78.1			
130.1			
106.1			
48.1			
366.10	+2.13	497.96	
400.10	+1.89	497.72	
371.1			
181.1			
231.1			
266.1			
128.1			
164.1			
400.10	-1.89	495.83	
321.60	0.00	497.72	
238.1			
231.1			

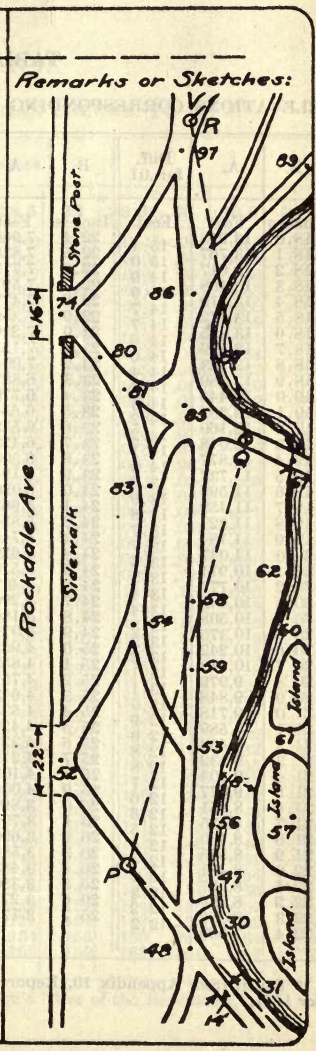


TABLE I.

ELEVATIONS CORRESPONDING TO BAROMETRIC READINGS.*

B.	A.	Diff. for .01	B.	A.	Diff. for .01.	B.	A.	Diff. for .01.
Inches	Feet	Feet	Inches	Feet	Feet	Inches	Feet	Feet
18.0	13,918		22.4	7,960		26.7	3,175	
18.1	13,767	−15.1	22.5	7,838	−12.2	26.8	3,073	−10.2
18.2	13,617	15.0	22.6	7,717	12.1	26.9	2,972	10.1
18.3	13,468	14.9	22.7	7,597	12.0	27.0	2,871	10.1
18.4	13,319	14.9	22.8	7,477	12.0	27.1	2,770	10.1
18.5	13,172	14.7	22.9	7,358	11.9	27.2	2,670	10.0
18.6	13,025	14.7	23.0	7,239	11.9	27.3	2,570	10.0
18.7	12,879	14.6	23.1	7,121	11.8	27.4	2,470	10.0
18.8	12,733	14.6	23.2	7,004	11.7	27.5	2,371	9.9
18.9	12,589	14.4	23.3	6,887	11 7	27.6	2,272	9.9
19.0	12,445	14.4	23.4	6,770	11.7	27.7	2,173	9.9
19.1	12,302	14.3	23.5	6,654	11.6	27.8	2,075	9.8
19.2	12,160	14.2	23.6	6,538	11.6	27.9	1 977	9.8
19.3	12,018	14.2	23.7	6,423	11.5	28.0	1,880	9.7
19.4	11,877	14.1	23.8	6,308	11.5	28.1	1,783	9.7
19.5	11,737	14.0	23.9	6,194	11.4	28.2	1,686	9.7
19.6	11,598	13.9	24.0	6,080	11.4	28.3	1,589	9.7
19.7	11,459	13.9	24.1	5,967	11.3	28.4	1,493	9 6
19.8	11,321	13.8	24.2	5,854	11.3	28.5	1,397	9.6
19.9	11,184	13.7	24.3	5,741	11.3	28.6	1,302	9.5
20.0	11,047	13.7	24.4	5,629	11.2	28.7	1,207	9.5
20.1	10,911	13.6	24.5	5,518	11.1	28.8	1,112	9.5
20.2	10,776	13.5	24.6	5,407	11.1	28.9	1,018	9.4
20.3	10,642	13.4	24.7	5,296	11.1	29.0	924	9.4
20.4	10,508	13.4	24.8	5,186	11.0	29.1	830	9.4
20.5	10,375	13.3	24.9	5,077	10.9	29.2	736	9.4
20.6	10,242	13.3	25.0	4,968	10.9	29.3	643	9.3
20.7	10,110	13.2	25.1	4,859	10.9	29.4	550	9.3
20.8	9,979	13.1	25.2	4,751	10.8	29.5	458	9.2
20.9	9,848	13.1	25.3	4,643	10.8	29.6	366	9.2
21.0	9,718	13.0	25.4	4,535	10.8	29.7	274	9.2
21.1	9,589	12.9	25.5	4,428	10.7	29.8	182	9.2
21.2	9,460	12.9	25.6	4,321	10.7	29.9	91	9.1
21.3	9,332	12.8	25.7	4,215	10.6	30.0	00	9.1
21.4	9,204	12.8	25.8	4,109	10.6	30.1	−91	9.1
21.5	9,077	12.7	25.9	4,004	10.5	30.2	181	9.0
21.6	8,951	12.6	26.0	3,899	10.5	30.3	271	9.0
21.7	8,825	12.6	26.1	3,794	10.5	30.4	361	9.0
21.8	8,700	12.5	26.2	3,690	10.4	30.5	451	9.0
21.9	8,575	12.5	26.3	3,586	10.4	30.6	540	8.9
22.0	8,451	12.4	26.4	3,483	10.3	30.7	629	8.9
22.1	8,327	12.4	26.5	3,380	10.3	30.8	717	8.8
22.2	8,204	12.3	26.6	3,277	10.3	30.9	805	8.8
22.3	8,082	12.2	26.7	3,175	−10.2	31.0	−893	−8.8
22.4	7,960	−12.2						

* Taken from Appendix 10, Report of U. S. Coast and Geodetic Survey for 1881.

TABLE II.

REDUCTION OF MERCURIAL COLUMN TO 32° F.*

Temp.	Inches.										
	26	26.5	27	27.5	28	28.5	29	29.5	30	30.5	31
45	−.038	−.039	−.040	−.041	−.041	−.042	−.043	−.044	−.044	−.045	−.046
46	.041	.042	.042	.043	.044	.045	.045	.046	.047	.048	.049
47	.043	.044	.045	.046	.046	.047	.048	.049	.050	.050	.052
48	.045	.046	.047	.048	.049	.050	.051	.051	.053	.053	.054
49	.048	.049	.050	.050	.051	.052	.053	.054	.055	.056	.057
50	.050	.051	.052	.053	.054	.055	.056	.057	.058	.059	.060
51	.052	.053	.054	.055	.056	.057	.058	.059	.060	.061	.063
52	.055	.056	.057	.058	.059	.060	.061	.062	.063	.064	.066
53	.057	.058	.059	.060	.061	.062	.064	.065	.066	.067	.068
54	.059	.060	.062	.063	.064	.065	.066	.067	.068	.070	.071
55	.062	.063	.064	.065	.066	.068	.069	.070	.071	.072	.074
56	.064	.065	.066	.068	.069	.070	.071	.073	.074	.075	.077
57	.067	.068	.069	070	.071	.073	.074	.075	.076	.078	.080
58	.069	.070	.071	.073	.074	.075	.076	.078	.079	080	.082
59	.071	.072	.074	.075	.076	.078	.079	.080	.082	.083	085
60	.074	.075	.076	077	.079	.080	.082	.083	.084	.086	.088
61	.076	.077	.078	.080	.081	.083	.084	.086	.087	.089	.091
62	.078	.079	.081	.082	.084	.085	.087	.088	.090	.091	.094
63	.080	.082	.083	.085	.086	.088	.089	.091	.092	.094	.096
64	.082	.084	.086	.087	.089	.090	.092	.094	.095	.097	.099
65	.085	.086	.088	.090	.091	.093	.095	.096	.098	.099	.102
66	.087	.089	.090	.092	.094	.095	.097	.099	.101	.102	.105
67	.089	.091	.093	.095	.096	.098	.100	.101	.103	.105	.108
68	.092	.093	.095	.097	.099	.101	.102	.104	.106	.108	.110
69	.094	.096	.098	.099	.101	.103	.105	.107	.109	.110	.113
70	.096	.098	.100	.102	.104	.106	.107	.109	.111	.113	.116
71	.099	.101	.102	.104	.106	.108	.110	.112	.114	.115	.119
72	.101	.103	.105	.107	.109	.111	.113	.115	.117	.118	.122
73	.103	.105	.107	.109	.111	.113	.115	.117	.119	.121	.124
74	.106	.108	.110	.112	.114	.116	.118	.121	.122	.124	.127
75	.108	.110	.112	.114	.116	.118	.120	.122	.125	.127	.130
76	.110	.112	.114	.117	.119	.121	.123	.125	.127	.129	.133
77	.113	.115	.117	.119	.121	.123	.126	.128	.130	.132	.136
78	.115	.117	.119	.121	.124	.126	.128	.130	.133	.135	.138
79	.117	.119	.122	.124	.126	.128	.131	.133	.135	.137	.141
80	.119	.122	124	.126	.129	.131	.133	.136	.138	.140	.144
81	.122	.124	.126	.129	.131	.133	.136	.138	.141	.143	.147
82	.124	.126	.129	.131	.134	.136	.138	.141	.143	.146	.149
83	.126	.129	.131	.134	.136	.139	.141	.143	.146	.148	.152
84	.129	.131	.134	.136	.139	.141	.144	.146	.148	.151	.155
85	.131	.134	.136	.139	.141	.144	.146	.149	151	.154	.158
86	.133	.136	.138	.141	.144	.146	.149	.151	.154	.156	161
87	.136	.138	.141	.143	.146	.149	.151	.154	.156	.159	.163
88	.138	.141	.143	.146	.149	.151	.154	.156	.159	.162	.166
89	.140	.143	.146	.148	.151	.154	.156	.159	.162	.164	.169
90	.143	.145	.148	.151	.153	.156	.159	.162	.164	.167	.172

* Compiled from R. S. Williamson's "Use of the Barometer."

TABLE III.

CORRECTION COEFFICIENTS TO BAROMETRIC ELEVATIONS FOR TEMPERATURE AND HUMIDITY.*

$t+t'$.	C.	Diff. for 1°.	$t+t'$.	C.	Diff. for 1°.	$t+t'$.	C.	Diff. for 1°.
0°	−0.1025	10.9	60°	−0.0380	10.7	120°	+0.0262	10.6
10°	− .0915	10.9	70°	− .0273	10.7	130°	+ .0368	10.4
20°	− .0806	10.8	80°	− .0166	10.8	140°	+ .0472	10.3
30°	− .0698	10.6	90°	− .0058	10.7	150	+ .0575	10.2
40	− .0592	10.6	100°	+ .0049	10.7	160°	+ .0677	10.2
50°	− .0486	10.6	110°	+ .0156	10.6	170°	+ .0779	10.0
60°	− .0380		120°	+ .0262		180°	+ .0879	

* Compiled from Tables I and IV, Report of U. S. Coast and Geodetic Survey for 1881.

TABLE IV.

MEAN REFRACTIONS (BESSEL).

TRUE FOR BAROMETER AT 30″; TEMPERATURE 50° F.

Alt.	Refr.	Alt.	Refr.	Alt.	Refr.	Alt.	Refr.
0° 00′	34′ 54″	6° 30′	7′ 54″	15° 00′	3′ 34″	27° 00′	1′ 54″
0 30	29 19	7 00	7 24	16 00	3 20	28 00	1 49
1 00	24 38	7 30	6 57	17 00	3 08	29 00	1 45
1 30	20 51	8 00	6 33	18 00	2 57	30 00	1 41
2 00	18 19	8 30	6 12	19 00	2 48	35 00	1 23
2 30	16 00	9 00	5 53	20 00	2 39	40 00	1 09
3 00	14 22	9 30	5 35	21 00	2 31	45 00	0 58
3 30	12 48	10 00	5 19	22 00	2 23	50 00	0 49
4 00	11 45	11 00	4 51	23 00	2 16	60 00	0 34
4 30	10 40	12 00	4 27	24 00	2 10	70 00	0 21
5 00	9 52	13 00	4 07	25 00	2 04	80 00	0 10
5 30	9 07	14 00	3 49	26 00	1 59	90 00	0 0
6 00	8 28						

TABLE V.

ERRORS IN AZIMUTH FOR ONE MINUTE ERROR IN DECLINATION OR LATITUDE.

No. of Hours from Noon.	For One Minute Error in Declination.			For One Minute Error in Latitude.		
	Lat. 30°.	Lat. 40°.	Lat. 50°.	Lat. 30°.	Lat. 40°.	Lat. 50°.
h. m.	Min.	Min.	Min.	Min.	Min.	Min.
0 30	8.85	10.00	12.90	8.77	9.92	11.80
1 00	4.46	5.05	6.01	4.33	4.87	5.80
2 00	2.31	2.61	3.11	2.00	2.26	2.70
3 00	1.63	1.85	2.20	1.15	1.30	1.56
4 00	1.34	1.51	1.80	0.67	0.75	0.90
5 00	1.20	1.35	1.61	0.31	0.35	0.37
6 00	1.15	1.30	1.56	0.00	0.00	0.00

TABLE VI.

REFRACTIONS IN TERMS OF LATITUDE, HOUR-ANGLE, AND SUN'S DECLINATION.

A TABLE OF MEAN REFRACTIONS IN DECLINATION TO BE USED WITH THE SOLAR ATTACHMENT.

Apply to the Declination as Found in the Ephemeris.

Hour-angle.	Declinations.								
	For Latitude 20°.								
	+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°
0 h	0″	05″	10″	15″	21″	27″	33″	40″	48″
2	03	07	13	18	24	30	36	44	52
3	06	13	18	24	30	36	44	52	1′ 02
4	17	22	28	35	42	50	1′ 00	1′ 11	1 26
5	39	47	57	1′ 07	1′ 20	1′ 37	2 00	2 32	3 25
	For Latitude 30°.								
0 h	13″	15″	21″	27″	33″	40″	48″	57″	1′ 08″
2	14	19	25	31	38	46	54	1′ 05	1 18
3	20	26	32	39	47	55	1′ 06	1 19	1 36
4	32	39	46	52	1′ 06	1′ 19	1 35	1 57	2 29
5	1′ 00	1′ 10	1′ 24	1′ 52	2 07	2 44	3 46	5 43	13 06
	For Latitude 40°.								
0 h	21″	27″	33″	40″	48″	57″	1′ 08″	1′ 21″	1′ 39″
2	25	32	39	46	52	1′ 06	1 19	1 35	1 57
3	33	40	48	57	1′ 08	1 21	1 38	2 02	2 36
4	47	55	1′ 06	1′ 19	1 36	1 58	2 30	3 21	4 59
5	1′ 15	1′ 31	1 51	2 20	3 05	4 25	7 34	25 18	
	For Latitude 50°.								
0 h	33″	40″	48″	57″	1′ 08″	1′ 21″	1′ 39″	2′ 02″	2′ 36″
2	38	46	55	1′ 06	1 18	1 35	1 57	2 28	3 19
3	47	56	1′ 06	1 19	1 36	2 29	2 31	3 23	5 02
4	1′ 02	1′ 14	1 29	1 48	2 16	2 58	4 18	6 59	19 47
5	1 30	1 51	2 19	3 04	4 22	7 28	24 10		
	For Latitude 60°.								
0 h	48″	57″	1′ 08″	1′ 21″	1′ 39″	2′ 02″	2′ 36″	3′ 33″	5′ 23″
2	54	1′ 04	1 17	1 33	1 54	2 24	3 12	4 38	8 15
3	1′ 03	1 15	1 30	1 51	2 20	3 04	4 24	7 31	24 44
4	1 18	1 34	1 56	2 28	3 18	4 50	8 53		
5	1 45	2 11	2 50	3 57	6 21	15 32			

TABLE VII.

AMOUNT AND VARIATION OF THE MAGNETIC NEEDLE FROM ITS MEAN DAILY POSITION.

The letters E and W indicate which side of the mean position the needle points.

Season and Position in Latitude.	Local Mean Time: Morning Hours.						
	6 h.	7 h.	8 h.	9 h.	10 h.	11 h.	12 h.
December, January, February:	Min.	Min.	Min.	Min.	Min.	Min.	Min.
Latitude 37° to 49°	0.7 E	1.1 E	1.9 E	2.2 E	1.5 E	0.1 W	1.8 W
Latitude 25° to 37°	0.1 W	0.1 E	1.0 E	2.0 E	2.2 E	1.1 E	0.5 W
March, April, May:							
Latitude 37° to 49°	2.6 E	3.8 E	4.4 E	3.5 E	1.2 E	1.6 E	3.8 W
Latitude 25° to 37°	1.6 E	2.8 E	3.3 E	2.6 E	1.1 E	0.6 W	1.9 W
June, July, August:							
Latitude 37° to 49°	4.0 E	5.6 E	5.7 E	4.5 E	1.7 E	1.6 E	4.1 W
Latitude 25° to 37°	2.4 E	4.0 E	4.2 E	2.9 E	0.5 E	1.6 W	2.8 W
September, October, November:							
Latitude 37° to 49°	1.8 E	2.6 E	3.1 E	2.5 E	1.0 E	1.5 E	3.3 W
Latitude 25° to 37°	0.9 E	2.1 E	2.6 E	2.1 E	0.6 E	0.9 E	2.1 W

Season and Position in Latitude.	Local Mean Time: Afternoon Hours.						
	0 h.	1 h.	2 h.	3 h.	4 h.	5 h.	6 h.
December, January February:	Min.	Min.	Min.	Min.	Min.	Min.	Min.
Latitude 37° to 49°	1.8 W	2.9 W	2.8 W	2.1 W	1.3 W	0.7 W	0.2 W
Latitude 25° to 37°	0.5 W	1.5 W	1.8 W	1.6 W	1.0 W	0.4 W	0.1 W
March, April, May:							
Latitude 37° to 49°	3.8 W	4.8 W	4.6 W	3.8 W	2.5 W	1.4 W	0.7 W
Latitude 25° to 37°	1.9 W	2.6 W	2.8 W	2.4 W	1.6 W	0.9 W	0.5 W
June, July, August:							
Latitude 37° to 49°	4.1 W	5.6 W	5.6 W	4.6 W	3.0 W	1.4 W	0.6 W
Latitude 25° to 37°	2.8 W	3.2 W	3.1 W	2.4 W	1.5 W	0.8 W	0.4 W
September, October, November:							
Latitude 37° to 49°	3.3 W	4.0 W	3.4 W	2.3 W	1.2 W	0.6 W	0.1 W
Latitude 25° to 37°	2.1 W	2.3 W	1.9 W	1.2 W	0.7 W	0.4 W	0.2 W

TABLE VIII.

REDUCTION OF STADIA READINGS

TO

HORIZONTAL DISTANCES

AND TO

DIFFERENCES OF ELEVATION.

This table was computed by Professor Arthur Winslow, State Geologist of Missouri.

TABLE VIII.

STADIA REDUCTIONS FOR READING 100.

Minutes.	0°		1°		2°		3°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0′	100.00	.00	99.97	1.74	99.88	3.49	99.73	5.23
2	"	.06	"	1.80	99.87	3.55	99.72	5.28
4	"	.12	"	1.86	"	3.60	99.71	5.34
6	"	.17	99.96	1.92	"	3.66	"	5.40
8	"	.23	"	1.98	99.86	3.72	99.70	5.46
10	"	.29	"	2.04	"	3.78	99.69	5.52
12	"	.35	"	2.09	99.85	3.84	"	5.57
14	"	.41	99.95	2.15	"	3.90	99.68	5.63
16	"	.47	"	2.21	99.84	3.95	"	5.69
18	"	.52	"	2.27	"	4.01	99.67	5.75
20	"	.58	"	2.33	99.83	4.07	99.66	5.80
22	"	.64	99.94	2.38	"	4.13	"	5.86
24	"	.70	"	2.44	99.82	4.18	99.65	5.92
26	99.99	.76	"	2.50	"	4.24	99.64	5.98
28	"	.81	99.93	2.56	99.81	4.30	99.63	6.04
30	"	.87	"	2.62	"	4.36	"	6.09
32	"	.93	"	2.67	99.80	4.42	99.62	6.15
34	"	.99	"	2.73	"	4.48	"	6.21
36	"	1.05	99.92	2.79	99.79	4.53	99.61	6.27
38	"	1.11	"	2.85	"	4.59	99.60	6.33
40	"	1.16	"	2.91	99.78	4.65	99.59	6.38
42	"	1.22	99.91	2.97	"	4.71	"	6.44
44	99.98	1.28	"	3.02	99.77	4.76	99.58	6.50
46	"	1.34	99.90	3.08	"	4.82	99.57	6.56
48	"	1.40	"	3.14	99.76	4.88	99.56	6.61
50	"	1.45	"	3.20	"	4.94	"	6.67
52	"	1.51	99.89	3.26	99.75	4.99	99.55	6.73
54	"	1.57	"	3.31	99.74	5.05	99.54	6.78
56	99.97	1.63	"	3.37	"	5.11	99.53	6.84
58	"	1.69	99.88	3.43	99.73	5.17	99.52	6.90
60	"	1.74	"	3.49	"	5.23	99.51	6.96
$c+f=$ .75	.75	.01	.75	.02	.75	.03	.75	.05
$c+f=1.00$	1.00	.01	1.00	.03	1.00	.04	1.00	.06
$c+f=1.25$	1.25	.02	1.25	.03	1.25	.05	1.25	.08

TABLE VIII.

STADIA REDUCTIONS FOR READING 100.

Minutes.	4°		5°		6°		7°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0	99.51	6.96	99.24	8.68	98.91	10.40	98.51	12.10
2	"	7.02	99.23	8.74	98.90	10.45	98.50	12.15
4	99.50	7.07	99.22	8.80	68.88	10.51	98.48	12.21
6	99.49	7.13	99.21	8.85	98.87	10.57	98.47	12.26
8	99.48	7.19	99.20	8.91	98.86	10 62	98.46	12.32
10	99.47	7.25	99.19	8.97	98.85	10.68	98.44	12.38
12	99.46	7.30	99.18	9.03	98.83	10.74	98.43	12.43
14	"	7.36	99.17	9.08	98.82	10.79	98.41	12.49
16	99.45	7.42	99.16	9.14	98.81	10.85	98.40	12.55
18	99.44	7.48	99.15	9.20	98.80	10.91	98.39	12.60
20	99.43	7.53	99.14	9.25	98.78	10.96	98.37	12.66
22	99.42	7.59	99.13	9.31	98.77	11.02	98.36	12.72
24	99.41	7.65	99.11	9.37	98.76	11.08	98.34	12.77
26	99.40	7.71	99.10	9.43	98.74	11.13	98.33	12.83
28	99.39	7.76	99.09	9.48	98.73	11.19	98.31	12.88
30	99.38	7.82	99.08	9.54	98.72	11.25	98.29	12.94
32	99.38	7.88	99.07	9.60	98.71	11.30	98.28	13.00
34	99.37	7.94	99.06	9.65	98.69	11.36	98.27	13.05
36	99.36	7.99	99.05	9.71	98.68	11.42	98.25	13.11
38	99.35	8.05	99.04	9.77	98.67	11.47	98.24	13.17
40	99.34	8.11	99.03	9.83	98.65	11.53	98.22	13.22
42	99.33	8.17	99.01	9.88	98.64	11.59	98.20	13.28
44	99.32	8.22	99.00	9.94	98.63	11.64	98.19	13.33
46	99.31	8.28	98.99	10.00	98.61	11.70	98.17	13.39
48	99.30	8.34	98.98	10.05	98.60	11.76	98.16	13.45
50	99.29	8.40	98.97	10.11	98.58	11.81	98.14	13.50
52	99.28	8.45	98.96	10.17	98.57	11.87	98.13	13.56
54	99.27	8.51	98.94	10.22	98 56	11.93	98.11	13.61
56	99.26	8.57	98.93	10.28	98.54	11.98	98.10	13.67
58	99.25	8.63	98.92	10.34	98.53	12.04	98.08	13.73
60	99.24	8.68	98.91	10.40	98.51	12.10	98.06	13.78
$c+f=$ .75	.75	.06	.75	.07	.75	.08	.74	.10
$c+f=1.00$	1.00	.08	.99	.09	.99	.11	.99	.13
$c+f=1.25$	1.25	.10	1.24	.11	1.24	.14	1.24	.16

TABLE VIII.

STADIA REDUCTIONS FOR READING 100.

Minutes.	8°		9°		10°		11°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0′	98.06	13.78	97.55	15.45	96.98	17.10	96.36	18.73
2	98.05	13.84	97.53	15.51	96.96	17.16	96 34	18.78
4	98.03	13.89	97.52	15.56	96.94	17.21	96.32	18.84
6	98.01	13.95	97.50	15.62	96.92	17.26	96.29	18.89
8	98.00	14.01	97.48	15.67	96.90	17.32	96.27	18.95
10	97.98	14.06	97.46	15.73	96.88	17.37	96.25	19.00
12	97.97	14.12	97.44	15.78	96.86	17.43	96.23	19.05
14	97.95	14.17	97.43	15.84	96.84	17.48	96.21	19.11
16	97.93	14.23	97.41	15.89	96.82	17.54	96.18	19.16
18	97.92	14.28	97.39	15.95	96.80	17.59	96.16	19.21
20	97.90	14.34	97.37	16.00	96.78	17.65	96.14	19.27
22	97.88	14.40	97.35	16.06	96.76	17.70	96.12	19.32
24	97.87	14.45	97.33	16.11	96.74	17.76	96.09	19.38
26	97.85	14.51	97.31	16.17	96.72	17.81	96.07	19.43
28	97.83	14.56	97.29	16.22	96.70	17.86	96.05	19.48
30	97.82	14.62	97.28	16.28	96.68	17.92	96.03	19.54
32	97.80	14.67	97.26	16.33	96.66	17.97	96.00	19.59
34	97.78	14.73	97.24	16.39	96.64	18.03	95 98	19.64
36	97.76	14.79	97.22	16.44	96.62	18.08	95.96	19.70
38	97.75	14.84	97.20	16.50	96.60	18.14	95.93	19.75
40	97.73	14.90	97.18	16.55	96.57	18.19	95.91	19.80
42	97.71	14.95	97.16	16.61	96.55	18.24	95.89	19.86
44	97.69	15.01	97.14	16.66	96.53	18.30	95.86	19.91
46	97.68	15.06	97.12	16.72	96.51	18.35	95.84	19.96
48	97.66	15.12	97.10	16.77	96.49	18.41	95.82	20.02
50	97.64	15.17	97.08	16.83	96.47	18.46	95.79	20.07
52	97.62	15.23	97.06	16.88	96.45	18.51	95.77	20.12
54	97.61	15.28	97.04	16.94	96.42	18.57	95.75	20.18
56	97.59	15.34	97.02	16.99	96.40	18.62	95.72	20.23
58	97.57	15.40	97.00	17.05	96.38	18.68	95.70	20.28
60	97.55	15.45	96.98	17.10	96.36	18.73	95.68	20.34
$c+f=$ .75	.74	.11	.74	.12	.74	.14	.73	.15
$c+f=1.00$	.99	.15	.99	.16	.98	.18	.98	.20
$c+f=1.25$	1.23	.18	1.23	.21	1.23	.23	1.22	.25

TABLE VIII.

STADIA REDUCTIONS FOR READING 100.

Minutes.	12°		13°		14°		15°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0′	95.68	20.34	94.94	21.92	94.15	23.47	93.30	25.00
2	95.65	20.39	94.91	21.97	94.12	23.52	93.27	25.05
4	95.63	20.44	94.89	22.02	94.09	23.58	93.24	25.10
6	95.61	20.50	94.86	22.08	94 07	23.63	93.21	25.15
8	95·58	20.55	94.84	22.13	94.04	23.68	93.18	25.20
10	95.56	20.60	94.81	22.18	94.01	23.73	93.16	25.25
12	95.53	20.66	94.79	22.23	93 98	23.78	93.13	25.30
14	95.51	20.71	94.76	22.28	93.95	23.83	93.10	25.35
16	95.49	20.76	94.73	22.34	93.93	23.88	93.07	25.40
18	95.46	20.81	94.71	22.39	93.90	23.93	93.04	25.45
20	95.44	20.87	94.68	22.44	93.87	23.99	93.01	25.50
22	95.41	20.92	94.66	22.49	93.84	24.04	92.98	25.55
24	95.39	20.97	94.63	22.54	93.81	24.09	92.95	25.60
26	95.36	21.03	94.60	22.60	93.79	24.14	92.92	25.65
28	95.34	21.08	94.58	22.65	93.76	24.19	92.89	25.70
30	95.32	21.13	94.55	22.70	93.73	24.24	92.86	25.75
32	95.29	21.18	94.52	22.75	93.70	24.29	92.83	25.80
34	95.27	21.24	94.50	22.80	93.67	24.34	92.80	25.85
36	95.24	21.29	94.47	22.85	93.65	24.39	92.77	25.90
38	95.22	21 34	94.44	22.91	93.62	24.44	92.74	25.95
40	95.19	21.39	94.42	22.96	93.59	24.49	92.71	26.00
42	95.17	21.45	94.39	23.01	93.56	24.55	92 68	26.05
44	95.14	21.50	94.36	23.06	93.53	24.60	92.65	26.10
46	95.12	21.55	94.34	23.11	93.50	24.65	92.62	26.15
48	95.09	21.60	94.31	23.16	93.47	24.70	92.59	26.20
50	95.07	21.66	94.28	23.22	93.45	24.75	92.56	26.25
52	95.04	21.71	94.26	23.27	93.42	24.80	92.53	26.30
54	95.02	21.76	94.23	23.32	93.39	24.85	92.49	26.35
56	94.99	21.81	94.20	23.37	93.36	24.90	92.46	26.40
58	94.97	21.87	94.17	23.42	93.33	24.95	92.43	26.45
60	94.94	21.92	94.15	23.47	93.30	25.00	92.40	26.50
$c+f=.75$	.73	.16	.73	.17	.73	.19	.72	.20
$c+f=1.00$	.98	.22	.97	.23	.97	.25	.96	.27
$c+f=1.25$	1.22	.27	1.21	.29	1.21	.31	1.20	.34

TABLE VIII.

STADIA REDUCTIONS FOR READING 100.

Minutes.	16°		17°		18°		19°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0′	92.40	26.50	91.45	27.96	90.45	29.39	89.40	30.78
2	92.37	26.55	91.42	28.01	90.42	29.44	89 36	30.83
4	92.34	26.59	91.39	28.06	90.38	29.48	89.33	30.87
6	92.31	26.64	91.35	28.10	90.35	29.53	89.29	30.92
8	92.28	26.69	91.32	28.15	90.31	29.58	89.26	30.97
10	92.25	26.74	91.29	28.20	90.28	29.62	89.22	31.01
12	92.22	26.79	91.26	28.25	90.24	29.67	89.18	31.06
14	92.19	26.84	91.22	28.30	90.21	29.72	89.15	31.10
16	92.15	26.89	91.19	28.34	90.18	29.76	89 11	31.15
18	92.12	26.94	91.16	28.39	90.14	29.81	89.08	31.19
20	92.09	26.99	91.12	28.44	90.11	29.86	89.04	31.24
22	92.06	27.04	91.09	28.49	90.07	29.90	89.00	31.28
24	92.03	27.09	91.06	28.54	90.04	29.95	88.96	31.33
26	92.00	27.13	91.02	28.58	90.00	30.00	88.93	31.38
28	91.97	27.18	90.99	28.63	89.97	30.04	88.89	31.42
30	91.93	27.23	90.96	28.68	89.93	30.09	88.86	31.47
32	91.90	27.28	90.92	28.73	89.90	30.14	88.82	31.51
34	91.87	27.33	90.89	28.77	89.86	30.19	88.78	31.56
36	91.84	27.38	90.86	28.82	89.83	30.23	88.75	31.60
38	91.81	27.43	90.82	28.87	89.79	30.28	88.71	31.65
40	91.77	27.48	90.79	28.92	89.76	30.32	88.67	31.69
42	91.74	27.52	90.76	28.96	89.72	30.37	88.64	31.74
44	91.71	27.57	90.72	29.01	89.69	30.41	88.60	31.78
46	91.68	27.62	90.69	29.06	89.65	30.46	88.56	31.83
48	91.65	27.67	90.66	29.11	89.61	30.51	88.53	31.87
50	91.61	27.72	90.62	29.15	89.58	30.55	88.49	31.92
52	91.58	27.77	90.59	29.20	89.54	30.60	88.45	31.96
54	91.55	27.81	90.55	29.25	89.51	30.65	88.41	32.01
56	91.52	27.86	90.52	29.30	89.47	30.69	88.38	32.05
58	91.48	27.91	90.48	29.34	89.44	30.74	88.34	32.09
60	91.45	27.96	90.45	29.39	89.40	30.78	88.30	32.14
$c+f=.75$	.72	.21	.72	.23	.71	.24	.71	.25
$c+f=1.00$	.96	.28	.95	.30	.95	.32	.94	.33
$c+f=1.25$	1.20	.36	1.19	.38	1.19	.40	1.18	.42

TABLE VIII.

STADIA REDUCTIONS FOR READING 100.

Minutes.	20°		21°		22°		23°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0′	88.30	32.14	87.16	33.46	85.97	34.73	84.73	35.97
2	88.26	32.18	87.12	33.50	85.93	34.77	84.69	36.01
4	88.23	32.23	87.08	33.54	85.89	34.82	84.65	36.05
6	88.19	32.27	87.04	33.59	85.85	34.86	84.61	36.09
8	88.15	32.32	87.00	33.63	85.80	34 90	84.57	36.13
10	88.11	32.36	86.96	33.67	85.76	34.94	84.52	36.17
12	88.08	32.41	86.92	33.72	85.72	34.98	84.48	36.21
14	88.04	32.45	86.88	33.76	85.68	35.02	84.44	36.25
16	88.00	32.49	86.84	33.80	85.64	35.07	84.40	36.29
18	87.96	32.54	86.80	33.84	85.60	35.11	84.35	36.33
20	87.93	32.58	86.77	33.89	85.56	35.15	84.31	36.37
22	87.89	32.63	86.73	33.93	85.52	35.19	84.27	36.41
24	87.85	32.67	86.69	33.97	85.48	35.23	84.23	36.45
26	87.81	32.72	86.65	34.01	85.44	35.27	84.18	36.49
28	87.77	32.76	86.61	34.06	85.40	35.31	84.14	36.53
30	87.74	32.80	86.57	34.10	85.36	35 36	84.10	36.57
32	87.70	32.85	86.53	34.14	85.31	35.40	84.06	36.61
34	87.66	32.89	86.49	34.18	85.27	35.44	84.01	36.65
36	87.62	32.93	86.45	34.23	85.23	35.48	83.97	36.69
38	87.58	32.98	86.41	34.27	85.19	35.52	83.93	36.73
40	87.54	33.02	86.37	34.31	85.15	35.56	83.89	36.77
42	87.51	33.07	86.33	34.35	85.11	35.60	83.84	36.80
44	87.47	33.11	86.29	34.40	85.07	35.64	83.80	36.84
46	87.43	33.15	86.25	34.44	85.02	35.68	83.76	36.88
48	87.39	33.20	86 21	34.48	84.98	35.72	83.72	36.92
50	87.35	33.24	86.17	34.52	84.94	35.76	83.67	36.96
52	87.31	33.28	86.13	34.57	84.90	35.80	83.63	37.00
54	87 27	33.33	86.09	34.61	84.86	35.85	83.59	37.04
56	87.24	33.37	86.05	34.65	84.82	35.89	83.54	37.08
58	87.20	33.41	86.01	34.69	84.77	35.93	83.50	37.12
60	87.16	33.46	85.97	34.73	84.73	35.97	83.46	37.16
$c+f=.75$	.70	.26	.70	.27	.69	.29	.69	.30
$c+f=1.00$	.94	.35	.93	.37	.92	.38	.92	.40
$c+f=1.25$	1.17	.44	1.16	.46	1.15	.48	1.15	.50

TABLE VIII.

STADIA REDUCTIONS FOR READING 100.

Minutes.	24°		25°		26°		27°	
	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.	Hor. Dist.	Diff. Elev.
0′	83.46	37.16	82.14	38.30	80.78	39.40	79.39	40.45
2	83.41	37.20	82.09	38.34	80.74	39.44	79.34	40.49
4	83.37	37.23	82.05	38.38	80.69	39.47	79.30	40.52
6	83.33	37.27	82.01	38.41	80.65	39.51	79.25	40.55
8	83.28	37.31	81.96	38.45	80.60	39.54	79.20	40.59
10	83.24	37.35	81.92	38.49	80.55	39.58	79.15	40.62
12	83.20	37.39	81.87	38.53	80.51	39.61	79.11	40.66
14	83.15	37.43	81.83	38.56	80.46	39.65	79.06	40.69
16	83.11	37.47	81.78	38 60	80.41	39.69	79.01	40.72
18	83.07	37.51	81.74	38.64	80.37	39.72	78.96	40.76
20	83.02	37.54	81.69	38.67	80.32	39.76	78.92	40.79
22	82.98	37.58	81.65	38.71	80.28	39.79	78.87	40.82
24	82.93	37.62	81.60	38.75	80.23	39.83	78.82	40.86
26	82.89	37.66	81.56	38.78	80.18	39.86	78.77	40.89
28	82.85	37.70	81.51	38.82	80.14	39.90	78.73	40.92
30	82.80	37.74	81.47	38.86	80.09	39.93	78.68	40.96
32	82.76	37.77	81.42	38.89	80.04	39.97	78.63	40.99
34	82.72	37.81	81.38	38.93	80.00	40.00	78.58	41.02
36	82.67	37.85	81.33	38.97	79.95	40.04	78.54	41.06
38	82.63	37.89	81.28	39.00	79.90	40.07	78.49	41.09
40	82.58	37.93	81.24	39.04	79.86	40.11	78.44	41.12
42	82.54	37.96	81.19	39.08	79.81	40.14	78.39	41.16
44	82.49	38.00	81.15	39.11	79.76	40.18	78.34	41.19
46	82.45	38.04	81.10	39.15	79.72	40.21	78.30	41.22
48	82.41	38.08	81.06	39.18	79.67	40.24	78.25	41.26
50	82.36	38.11	81.01	39.22	79.62	40.28	78.20	41.29
52	82.32	38.15	80.97	39.26	79.58	40.31	78.15	41.32
54	82.27	38.19	80.92	39.29	79.53	40.35	78.10	41.35
56	82.23	38.23	80.87	39.33	79.48	40.38	78.06	41.39
58	82.18	38.26	80.83	39.36	79.44	40.42	78.01	41.42
60	82.14	38.30	80.78	39.40	79.39	40.45	77.96	41.45
$c+f=.75$	.68	.31	.68	.32	.67	.33	.66	.35
$c+f=1.00$	.91	.41	.90	.43	.89	.45	.89	.46
$c+f=1.25$	1.14	.52	1.13	.54	1.12	.56	1.11	.58

TABLE IX.

LOCAL MEAN (ASTRONOMICAL) TIME OF THE CULMINATIONS AND ELONGATIONS OF POLARIS IN THE YEAR 1915.

(Computed for latitude 40° north and longitude 90° or 6 h. west of Greenwich.)

Date.	East elongation.	Upper culmination.	West elongation.	Lower culmination.
1915	h m	h m	h m	h m
January 1	0 51.7	6 46.9	12 42.1	18 44.9
January 15	23 52.5	5 51.6	11 46.8	17 49.6
February 1	22 45.3	4 44.5	10 39.7	16 42.5
February 15	21 50.1	3 49.2	9 44.4	15 47.2
March 1	20 54.8	2 54.0	8 49.2	14 52.0
March 15	19 59.6	1 58.8	7 54.0	13 56.8
April 1	18 52.7	0 51.9	6 47.1	12 49.9
April 15	17 57.7	23 52.9	5 52.0	11 54.8
May 1	16 54.8	22 50.0	4 49.2	10 52.0
May 15	15 59.9	21 55.1	3 54.2	9 57.0
June 1	14 53.3	20 48.5	2 47.6	8 50.4
June 15	13 58.5	19 53.7	1 52.8	7 55.6
July 1	12 55.9	18 51.1	0 50.2	6 53.0
July 15	12 01.1	17 56.3	23 51.5	5 58.2
August 1	10 54.5	16 49.7	22 44.9	4 51.7
August 15	9 59.8	15 55.0	21 50.2	3 56.9
September 1	8 53.2	14 48.4	20 43.6	2 50.3
September 15	7 58.3	13 53.5	19 48.7	1 55.4
October 1	6 55.5	12 50.7	18 45.9	0 52.7
October 15	6 00.6	11 55.8	17 51.0	23 53.8
November 1	4 53.7	10 48.9	16 44.1	22 46.9
November 15	3 58.6	9 53.8	15 49.0	21 51.8
December 1	2 55.6	8 50.8	14 46.0	20 48.8
December 15	2 00.4	7 55.6	13 50.8	19 53.6

A. *To refer the above tabular quantities to years other than* 1915.

1914	subtract	1.5 minutes	
1916	add	1.6 "	up to March 1.
	subtract	2.3 "	on and after March 1.
1917	subtract	0.7 "	
1918	add	0.9 "	
1919	add	2.5 "	
1920	add	4.0 "	up to March 1.
	add	0.1 "	on and after March 1.
1921	add	1.6 "	
1922	add	3.1 "	
1923	add	4.5 "	

1924	add	5.9 minutes	up to March 1.
	add	2.0 "	on and after March 1.
1925	add	3.3 "	
1926	add	4.6 "	
1927	add	5.9 "	
1928	add	7.2 "	up to March 1.
	add	3.3 "	on and after March 1.

B. *To refer to any calendar day other than the first and fifteenth of each month* SUBTRACT *the quantities below from the tabular quantity for the* PRECEDING DATE, *or* ADD *to the tabular quantity for the* FOLLOWING DATE:

Day of month.	Minutes.	No. of days elapsed.	Day of month.	Minutes.	No. of days elapsed.
2 or 16	3.9	1	10 or 24	35.3	9
3 17	7.8	2	11 25	39.2	10
4 18	11.8	3	12 26	43.1	11
5 19	15.7	4	13 27	47.0	12
6 20	19.6	5	14 28	51.0	13
7 21	23.5	6	29	54.9	14
8 22	27.4	7	30	58.8	15
9 23	31.4	8	31	62.7	16

C. *To refer the table to Standard time and to the civil or common method of reckoning*:

(*a*) ADD to the tabular quantities four minutes for every degree of longitude the place is west of the Standard meridian, and SUBTRACT when the place is east of the Standard meridian.

(*b*) The astronomical day begins twelve hours after the civil day, i.e., begins at noon on the civil day of the same date, and is reckoned from 0 to 24 hours. Consequently, an astronomical time less than twelve hours refers to the same civil day, whereas an astronomical time greater than twelve hours refers to the morning of the next civil day.

It will be noticed that for the tabular year two eastern elongations occur on January 14 and two western elongations on July 13. There are also two upper culminations on April 14 and two lower culminations on October 14. The lower culmination either follows or precedes the upper culmination by 11 h. 58.0 m.

D. *To refer to any other than the tabular latitude between the limits of* 10° *and* 50° *north*: ADD to the time of west elongation 0.10 m. for every degree south of 40° and SUBTRACT from the time of west elongation 0.16 m. for every degree north of 40°. Reverse these operations for correcting times of east elongation.

E. *To refer to any other than the tabular longitude*: ADD 0.16 m. for each 15° east of the ninetieth meridian and SUBTRACT 0.16 m. for each 15° west of the ninetieth meridian.

TABLE X.—AZIMUTH OF POLARIS WHEN AT ELONGATION FOR ANY YEAR BETWEEN 1914 AND 1928.

Latitude.	1914	1915	1916	1917	1918	1919	1920	1921
°	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
25	16.4	16.0	15.7	15.3	15.0	14.7	14.3	14.0
26	17.0	16.6	16.3	16.0	15.6	15.3	14.9	14.7
27	17.7	17.3	17.0	16.6	16.3	15.9	15.6	15.2
28	18.4	18.0	17.7	17.3	17.0	16.6	16.3	15.9
29	19.1	18.8	18.4	18.1	17.7	17.4	17.0	16.6
30	19.9	19.6	19.2	18.8	18.5	18.1	17.8	17.4
31	20.7	20.4	20.0	19.7	19.3	18.9	18.6	18.2
32	21.6	21.2	20.9	20.5	20.1	19.8	19.4	19.1
33	22.5	22.1	21.8	21.4	21.0	20.7	20.3	19.9
34	23.5	23.1	22.7	22.4	22.0	21.6	21.2	20.9
35	24.5	24.1	23.7	23.3	23.0	22.6	22.2	21.8
36	25.5	25.2	24.8	24.4	24.0	23.6	23.3	22.9
37	26.7	26.3	25.9	25.3	25.1	24.7	24.3	24.0
38	27.8	27.4	27.0	26.6	26.2	25.9	25.5	25.1
39	29.0	28.6	28.2	27.8	27.5	27.1	26.7	26.3
40	30.3	29.9	29.5	29.1	28.7	28.3	27.9	27.5
41	31.7	31.3	30.9	30.4	30.0	29.6	29.1	28.8
42	33.1	32.7	32.3	31.9	31.5	31.0	30.6	30.2
43	34.6	34.2	33.8	33.4	32.9	32.5	32.1	31.8
44	36.2	35.8	35.3	34.9	34.5	34.1	33.6	33.2
45	37.8	37.4	37.0	36.6	36.1	35.7	35.3	34.8
46	39.6	39.2	38.7	38.3	37.8	37.4	37.0	36.5
47	41.5	41.0	40.6	40.1	39.7	39.2	38.8	38.3
48	43.4	43.0	42.5	42.0	41.6	41.1	40.7	40.2
49	45.5	45.0	44.5	44.1	43.6	43.1	42.7	42.2
50	1 47.7	1 47.2	1 46.7	1 46.2	1 45.7	1 45.3	1 44.8	1 44.3

TABLE X.—AZIMUTH OF POLARIS WHEN AT ELONGATION FOR ANY YEAR BETWEEN 1914 AND 1928—*Continued.*

Latitude.	1922	1923	1924	1925	1926	1927	1928
°	° ′	° ′	° ′	° ′	° ′	° ′	° ′
25	13.6	13.3	13.0	12.6	12.3	11.9	11.6
26	14.2	13.9	13.6	13.2	12.9	12.5	12.2
27	14.9	14.6	14.2	13.9	13.5	13.2	12.8
28	15.6	15.2	14.9	14.6	14.2	13.8	13.5
29	16.3	16.0	15.6	15.2	14.9	14.6	14.2
30	17.0	16.7	16.4	16.0	15.6	15.3	14.9
31	17.9	17.5	17.2	16.8	16.4	16.1	15.7
32	18.7	18.3	18.0	17.6	17.2	16.9	16.5
33	19.6	19.2	18.8	18.5	18.1	17.8	17.4
34	20.5	20.1	19.8	19.4	19.0	18.6	18.3
35	21.5	21.1	20.7	20.4	20.0	19.6	19.2
36	22.5	22.1	21.7	21.4	21.0	20.6	20.2
37	23.6	23.2	22.8	22.4	22.0	21.6	21.3
38	24.7	24.3	23.9	23.5	23.2	22.8	22.4
39	25.8	25.5	25.1	24.7	24.3	23.9	23.5
40	27.1	26.7	26.3	25.9	25.5	25.1	24.7
41	28.4	28.0	27.6	27.2	26.8	26.4	26.0
42	29.8	29.4	29.0	28.6	28.2	27.8	27.3
43	31.2	30.8	30.4	30.0	29.6	29.1	28.7
44	32.8	32.4	31.9	31.5	31.1	30.6	30.2
45	34.4	34.0	33.5	33.1	32.6	32.2	31.8
46	36.1	35.6	35.2	34.8	34.3	33.9	33.4
47	37.9	37.4	37.0	36.5	36.1	35.6	35.2
48	39.8	39.3	38.8	38.4	37.9	37.4	37.0
49	41.7	41.3	40.8	40.3	39.9	39.4	38.9
50	1 43.8	1 43.4	1 42.9	1 42.4	1 41.9	1 41.4	1 41.0

The above table was computed with the mean declination of Polaris for each year. A more accurate result will be had by applying to the tabular values the following corrections, which depend on the difference of the mean and the apparent place of the star. The deduced azimuth will, in general, be correct within 0′.3.

For middle of	Correction.	For middle of	Correction.
	′		′
January	−0.5	July	+0.2
February	−0.4	August	+0.1
March	−0.3	September	−0.1
April	0.0	October	−0.4
May	+0.1	November	−0.6
June	+0.2	December	−0.8

N.		0	1	2	3	4	5	6	7	8	9	P. P.				
100	00	000	043	087	130	173	217	260	303	346	389					
													43	43	42	41
01		432	475	518	561	604	646	689	732	775	817	.1	4.3	4.3	4.2	4.1
02		860	902	945	987	*030	*072	*114	*157	*199	*241	.2	8.7	8.6	8.4	8.2
03	01	283	326	368	410	452	494	536	578	619	661	.3	13.0	12.9	12.6	12.3
04		703	745	787	828	870	911	953	994	*036	*077	.4	17.4	17.2	16.8	16.4
05	02	119	160	201	243	284	325	366	407	448	489	.5	21.7	21.5	21.0	20.5
06		530	571	612	653	694	735	775	816	857	898	.6	26.1	25.8	25.2	24.6
07		938	979	*019	*060	*100	*141	*181	*221	*262	*302	.7	30.4	30.1	29.4	28.7
08	03	342	382	422	463	503	543	583	623	663	703	.8	34.8	34.4	33.6	32.8
09		742	782	822	862	901	941	981	*020	*060	*100	.9	39.1	38.7	37.8	36.9
110	04	139	178	218	257	297	336	375	415	454	493					
													40	40	39	38
11		532	571	610	649	688	727	766	805	844	883	.1	4.0	4.0	3.9	3.8
12		922	960	999	*038	*076	*115	*154	*192	*231	*269	.2	8.1	8.0	7.8	7.6
13	05	308	346	384	423	461	499	538	576	614	652	.3	12.1	12.0	11.7	11.4
14		690	728	766	804	842	880	918	956	994	*032	.4	16.2	16.0	15.6	15.2
15	06	070	107	145	183	220	258	296	333	371	408	.5	20.2	20.0	19.5	19.0
16		446	483	520	558	595	632	670	707	744	781	.6	24.3	24.0	23.4	22.8
17		818	855	893	930	967	*004	*040	*077	*114	*151	.7	28.3	28.0	27.3	26.6
18	07	188	225	261	298	335	372	408	445	481	518	.8	32.4	32.0	31.2	30.4
19		554	591	627	664	700	737	773	809	845	882	.9	36.4	36.0	35.1	34.2
120		918	954	990	*026	*062	*098	*134	*170	*206	*242					
													37	37	36	35
21	08	278	314	350	386	422	457	493	529	564	600	.1	3.7	3.7	3.6	3.5
22		636	671	707	742	778	813	849	884	920	955	.2	7.5	7.4	7.2	7.0
23		990	*026	*061	*096	*131	*166	*202	*237	*272	*307	.3	11.2	11.1	10.8	10.5
24	09	342	377	412	447	482	517	552	586	621	656	.4	15.0	14.8	14.4	14.0
25		691	725	760	795	830	864	899	933	968	*002	.5	18.7	18.5	18.0	17.5
26	10	037	071	106	140	174	209	243	277	312	346	.6	22.5	22.2	21.6	21.0
27		380	414	448	483	517	551	585	619	653	687	.7	26.2	25.9	25.2	24.5
28		721	755	789	822	856	890	924	958	991	*025	.8	30.0	29.6	28.8	28.0
29	11	059	092	126	160	193	227	260	294	327	361	.9	33.7	33.3	32.4	31.5
130		394	427	461	494	528	561	594	627	661	694					
													34	34	33	32
31		727	760	793	826	859	892	925	958	991	*024	.1	3.4	3.4	3.3	3.2
32	12	057	090	123	156	189	221	254	287	320	352	.2	6.9	6.8	6.6	6.4
33		385	418	450	483	515	548	580	613	645	678	.3	10.3	10.2	9.9	9.6
34		710	743	775	807	840	872	904	937	969	*001	.4	13.8	13.6	13.2	12.8
35	13	033	065	097	130	162	194	226	258	290	322	.5	17.2	17.0	16.5	16.0
36		354	386	417	449	481	513	545	577	608	640	.6	20.7	20.4	19.8	19.2
37		672	703	735	767	798	830	862	893	925	956	.7	24.1	23.8	23.1	22.4
38		988	*019	*051	*082	*113	*145	*176	*207	*239	*270	.8	27.6	27.2	26.4	25.6
39	14	301	332	364	395	426	457	488	519	550	582	.9	31.0	30.6	29.7	28.8
140		613	644	675	706	736	767	798	829	860	891					
													31	31	30	29
41		922	952	983	*014	*045	*075	*106	*137	*167	*198	.1	3.1	3.1	3.0	2.9
42	15	229	259	290	320	351	381	412	442	473	503	.2	6.3	6.2	6.0	5.8
43		533	564	594	624	655	685	715	745	776	806	.3	9.4	9.3	9.0	8.7
44		836	866	896	926	956	987	*017	*047	*077	*107	.4	12.6	12.4	12.0	11.6
45	16	137	166	196	226	256	286	316	346	376	405	.5	15.7	15.5	15.0	14.5
46		435	465	494	524	554	584	613	643	672	702	.6	18.9	18.6	18.0	17.4
47		731	761	791	820	849	879	908	938	967	997	.7	22.0	21.7	21.0	20.3
48	17	026	055	085	114	143	172	202	231	260	289	.8	25.2	24.8	24.0	23.2
49		318	348	377	406	435	464	493	522	551	580	.9	28.3	27.9	27.0	26.1
150		609	638	667	696	725	753	782	811	840	869					

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150	17 609	638	667	696	725	753	782	811	840	869	29 28 27
151	897	926	955	984	*012	*041	*070	*098	*127	*156	.1 2.9 2.8 2.7
152	18 184	213	241	270	298	327	355	384	412	440	.2 5.8 5.6 5.4
153	469	497	526	554	582	611	639	667	695	724	.3 8.7 8.4 8.1
154	752	780	808	836	864	893	921	949	977	*005	.4 11.6 11.2 10.8
155	19 033	061	089	117	145	173	201	229	256	284	.5 14.5 14.0 13.5
156	312	340	368	396	423	451	479	507	534	562	.6 17.4 16.8 16.2
157	590	617	645	673	700	728	755	783	810	838	.7 20.3 19.6 18.9
158	865	893	920	948	975	*003	*030	*057	*085	*112	.8 23.2 22.4 21.6
159	20 139	167	194	221	249	276	303	330	357	385	.9 26.1 25.2 24.3
160	412	439	466	493	520	547	574	601	628	655	26 26
161	682	709	736	763	790	817	844	871	898	924	.1 2.6 2.6
162	951	978	*005	*032	*058	*085	*112	*139	*165	*192	.2 5.3 5.2
163	21 219	245	272	298	325	352	378	405	431	458	.3 7.9 7.8
164	484	511	537	564	590	616	643	669	695	722	.4 10.6 10.4
165	748	774	801	827	853	880	906	932	958	984	.5 13.2 13.0
166	22 011	037	063	089	115	141	167	193	219	245	.6 15.9 15.6
167	271	297	323	349	375	401	427	453	479	505	.7 18.5 18.2
168	531	557	582	608	634	660	686	711	737	763	.8 21.2 20.8
169	788	814	840	865	891	917	942	968	994	*019	.9 23.8 23.4
170	23 045	070	096	121	147	172	198	223	249	274	25 25 24
171	299	325	350	375	401	426	451	477	502	527	.1 2.5 2.5 2.4
172	553	578	603	628	653	679	704	729	754	779	.2 5.1 5.0 4.8
173	804	829	855	880	905	930	955	980	*005	*030	.3 7.6 7.5 7.2
174	24 055	080	105	129	154	179	204	229	254	279	.4 10.2 10.0 9.6
175	304	328	353	378	403	427	452	477	502	526	.5 12.7 12.5 12.0
176	551	576	600	625	650	674	699	723	748	773	.6 15.3 15.0 14.4
177	797	822	846	871	895	920	944	968	993	*017	.7 17.8 17.5 16.8
178	25 042	066	091	115	139	164	188	212	237	261	.8 20.4 20.0 19.2
179	285	309	334	358	382	406	430	455	479	503	.9 22.9 22.5 21.6
180	527	551	575	599	623	647	672	696	720	744	24 23
181	768	792	816	840	863	887	911	935	959	983	.1 2.4 2.3
182	26 007	031	055	078	102	126	150	174	197	221	.2 4.7 4.6
183	245	269	292	316	340	363	387	411	434	458	.3 7.0 6.9
184	482	505	529	552	576	599	623	646	670	693	.4 9.4 9.2
185	717	740	764	787	811	834	858	881	904	928	.5 11.7 11.5
186	951	974	998	*021	*044	*068	*091	*114	*137	*161	.6 14.1 13.8
187	27 184	207	230	254	277	300	323	346	369	392	.7 16.4 16.1
188	416	439	462	485	508	531	554	577	600	623	.8 18.8 18.4
189	646	669	692	715	738	761	784	806	829	852	.9 21.1 20.7
190	875	898	921	944	966	989	*012	*035	*058	*080	22 22 21
191	28 103	126	149	171	194	217	239	262	285	307	.1 2.2 2.2 2.1
192	330	352	375	398	420	443	465	488	510	533	.2 4.5 4.4 4.3
193	555	578	600	623	645	668	690	713	735	758	.3 6.7 6.6 6.4
194	780	802	825	847	869	892	914	936	959	981	.4 9.0 8.8 8.6
195	29 003	025	048	070	092	114	137	159	181	203	.5 11.2 11.0 10.7
196	225	248	270	292	314	336	358	380	402	424	.6 13.5 13.2 12.9
197	446	468	490	512	534	556	578	600	622	644	.7 15.7 15.4 15.0
198	666	688	710	732	754	776	798	820	841	863	.8 18.0 17.6 17.2
199	885	907	929	950	972	994	*016	*038	*059	*081	.9 20.2 19.8 19.3
200	30 103	124	146	168	190	211	233	254	276	298	

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00	30 103	124	146	168	190	211	233	254	276	298	
											22 21
01	319	341	363	384	406	427	449	470	492	513	.1 2.2 2.1
02	535	556	578	599	621	642	664	685	707	728	.2 4.4 4.2
03	749	771	792	813	835	856	878	899	920	941	.3 6.6 6.3
04	963	984	*005	*027	*048	*069	*090	*112	*133	*154	.4 8.8 8.4
05	31 175	196	217	239	260	281	302	323	344	365	.5 11.0 10.5
06	386	408	429	450	471	492	513	534	555	576	.6 13.2 12.6
07	597	618	639	660	681	702	722	743	764	785	.7 15.4 14.7
08	806	827	848	869	890	910	931	952	973	994	.8 17.6 16.8
09	32 014	035	056	077	097	118	139	160	180	201	.9 19.8 18.9
10	222	242	263	284	304	325	346	366	387	407	
											20 20
11	428	449	469	490	510	531	551	572	592	613	.1 2.0 2.0
12	633	654	674	695	715	736	756	776	797	817	.2 4.1 4.0
13	838	858	878	899	919	940	960	980	*001	*021	.3 6.1 6.0
14	33 041	061	082	102	122	142	163	183	203	223	.4 8.2 8.0
15	244	264	284	304	324	344	365	385	405	425	.5 10.2 10.0
16	445	465	485	505	525	546	566	586	606	626	.6 12.3 12.0
17	646	666	686	706	726	746	766	786	806	825	.7 14.3 14.0
18	845	865	885	905	925	945	965	985	*004	*024	.8 16.4 16.0
19	34 044	064	084	104	123	143	163	183	203	222	.9 18.4 18.0
20	242	262	281	301	321	341	360	380	400	419	
											19 19
21	439	459	478	498	518	537	557	576	596	615	.1 1.9 1.9
22	635	655	674	694	713	733	752	772	791	811	.2 3.9 3.8
23	830	850	869	889	908	928	947	966	986	*005	.3 5.8 5.7
24	35 025	044	063	083	102	121	141	160	179	199	.4 7.8 7.6
25	218	237	257	276	295	314	334	353	372	391	.5 9.7 9.5
26	411	430	449	468	487	507	526	545	564	583	.6 11.7 11.4
27	602	621	641	660	679	698	717	736	755	774	.7 13.6 13.3
28	793	812	831	850	869	888	907	926	945	964	.8 15.6 15.2
29	983	*002	*021	*040	*059	*078	*097	*116	*135	*154	.9 17.5 17.1
30	36 173	191	210	229	248	267	286	305	323	342	
											18 18
31	361	380	399	417	436	455	474	492	511	530	.1 1.8 1.8
32	549	567	586	605	623	642	661	679	698	717	.2 3.7 3.6
33	735	754	773	791	810	828	847	866	884	903	.3 5.5 5.4
34	921	940	958	977	996	*014	*033	*051	*070	*088	.4 7.4 7.2
35	37 107	125	143	162	180	199	217	236	254	273	.5 9.2 9.0
36	291	309	328	346	364	383	401	420	438	456	.6 11.1 10.8
37	475	493	511	530	548	566	584	603	621	639	.7 12.9 12.6
38	657	676	694	712	730	749	767	785	803	821	.8 14.8 14.4
39	840	858	876	894	912	930	948	967	985	*003	.9 16.6 16.2
40	38 021	039	057	075	093	111	129	147	165	183	
											17 17
41	201	219	237	255	273	291	309	327	345	363	.1 1.7 1.7
42	381	399	417	435	453	471	489	507	525	543	.2 3.5 3.4
43	560	578	596	614	632	650	667	685	703	721	.3 5.2 5.1
44	739	757	774	792	810	828	845	863	881	899	.4 7.0 6.8
45	916	934	952	970	987	*005	*023	*040	*058	*076	.5 8.7 8.5
46	39 093	111	129	146	164	181	199	217	234	252	.6 10.5 10.2
47	269	287	305	322	340	357	375	392	410	427	.7 12.2 11.9
48	445	462	480	497	515	532	550	567	585	602	.8 14.0 13.6
49	620	637	655	672	689	707	724	742	759	776	.9 15.7 15.3
50	794	811	828	846	863	881	898	915	933	950	
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250	39 794	81$\bar{1}$	82$\bar{8}$	846	86$\bar{3}$	881	898	91$\bar{5}$	933	950	
251	96$\bar{7}$	98$\bar{4}$	*002	*019	*03$\bar{6}$	*054	*071	*08$\bar{8}$	*10$\bar{5}$	*123	
252	40 140	157	17$\bar{4}$	19$\bar{1}$	209	226	243	260	277	295	17 17
253	312	329	34$\bar{6}$	36$\bar{3}$	38$\bar{0}$	398	415	432	449	46$\bar{6}$	.1 1.7 1.7
254	48$\bar{3}$	50$\bar{0}$	51$\bar{7}$	53$\bar{4}$	55$\bar{1}$	569	586	603	620	637	.2 3.5 3.4
255	654	671	688	705	722	739	75$\bar{6}$	773	790	807	.3 5.2 5.1
256	824	841	858	875	892	90$\bar{8}$	92$\bar{5}$	94$\bar{2}$	95$\bar{9}$	976	.4 7.0 6.8
257	99$\bar{3}$	*010	*027	*04$\bar{4}$	*06$\bar{1}$	*077	*094	*11$\bar{1}$	*12$\bar{8}$	*145	.5 8.7 8.5
258	41 162	179	19$\bar{5}$	21$\bar{2}$	22$\bar{9}$	246	263	279	296	31$\bar{3}$	.6 10.5 10.2
259	330	346	36$\bar{3}$	380	397	413	430	447	464	48$\bar{0}$	.7 12.2 11.9
											.8 14.0 13.6
260	49$\bar{7}$	514	53$\bar{0}$	54$\bar{7}$	564	581	59$\bar{7}$	614	631	64$\bar{7}$	.9 15.7 15.3
261	664	68$\bar{0}$	69$\bar{7}$	714	73$\bar{0}$	747	764	78$\bar{0}$	797	81$\bar{3}$	
262	830	84$\bar{6}$	86$\bar{3}$	880	89$\bar{6}$	913	92$\bar{9}$	946	96$\bar{2}$	979	
263	99$\bar{5}$	*012	*02$\bar{8}$	*045	*06$\bar{1}$	*078	*094	*11$\bar{1}$	*12$\bar{7}$	*144	
264	42 160	177	19$\bar{3}$	209	226	24$\bar{2}$	259	275	292	308	
265	32$\bar{4}$	341	357	373	390	406	423	439	45$\bar{5}$	472	
266	488	50$\bar{4}$	521	537	55$\bar{3}$	56$\bar{9}$	586	602	618	635	16 16
267	651	66$\bar{7}$	68$\bar{3}$	700	71$\bar{6}$	73$\bar{2}$	74$\bar{8}$	765	781	79$\bar{7}$	.1 1.6 1.6
268	81$\bar{3}$	82$\bar{9}$	846	862	87$\bar{8}$	894	910	927	943	959	.2 3.2 3.2
269	975	99$\bar{1}$	*007	*02$\bar{3}$	*040	*056	*072	*088	*104	*12$\bar{0}$	.3 4.9 4.8
											.4 6.6 6.4
270	43 13$\bar{6}$	15$\bar{2}$	16$\bar{8}$	18$\bar{4}$	20$\bar{0}$	21$\bar{6}$	233	249	265	281	.5 8.2 8.0
											.6 9.9 9.6
271	297	313	329	345	36$\bar{1}$	377	393	409	425	441	.7 11.5 11.2
272	457	473	489	505	52$\bar{0}$	53$\bar{6}$	55$\bar{2}$	56$\bar{8}$	58$\bar{4}$	60$\bar{0}$	.8 13.2 12.8
273	61$\bar{6}$	632	648	664	680	69$\bar{5}$	71$\bar{1}$	727	74$\bar{3}$	759	.9 14.8 14.4
274	775	791	806	822	83$\bar{8}$	854	870	886	90$\bar{1}$	917	
275	933	949	965	980	996	*012	*028	*043	*059	*07$\bar{5}$	
276	44 091	10$\bar{6}$	12$\bar{2}$	138	154	16$\bar{9}$	185	201	21$\bar{6}$	23$\bar{2}$	
277	248	26$\bar{3}$	27$\bar{9}$	29$\bar{5}$	31$\bar{0}$	32$\bar{6}$	342	35$\bar{7}$	37$\bar{3}$	389	
278	40$\bar{4}$	420	43$\bar{5}$	45$\bar{1}$	46$\bar{7}$	48$\bar{2}$	498	51$\bar{3}$	52$\bar{9}$	545	
279	56$\bar{0}$	576	59$\bar{1}$	607	62$\bar{2}$	638	65$\bar{3}$	669	685	70$\bar{0}$	15 15
											.1 1.5 1.5
280	716	73$\bar{1}$	747	76$\bar{2}$	778	79$\bar{3}$	809	824	83$\bar{9}$	855	.2 3.1 3.0
											.3 4.6 4.5
281	87$\bar{0}$	88$\bar{6}$	90$\bar{1}$	917	93$\bar{2}$	948	96$\bar{3}$	97$\bar{8}$	994	*00$\bar{9}$	.4 6.2 6.0
282	45 025	040	05$\bar{5}$	071	08$\bar{6}$	102	117	13$\bar{2}$	148	16$\bar{3}$	.5 7.7 7.5
283	17$\bar{8}$	194	20$\bar{9}$	22$\bar{4}$	240	255	27$\bar{0}$	286	301	31$\bar{6}$	.6 9.3 9.0
284	33$\bar{2}$	34$\bar{7}$	36$\bar{2}$	37$\bar{7}$	39$\bar{3}$	408	42$\bar{3}$	43$\bar{8}$	454	469	.7 10.8 10.5
285	48$\bar{4}$	49$\bar{9}$	515	530	54$\bar{5}$	56$\bar{0}$	576	591	606	62$\bar{1}$	.8 12.4 12.0
286	636	652	667	682	69$\bar{7}$	712	727	743	758	773	.9 13.9 13.5
287	788	80$\bar{3}$	81$\bar{8}$	83$\bar{3}$	84$\bar{8}$	86$\bar{4}$	87$\bar{9}$	894	909	924	
288	939	954	96$\bar{9}$	98$\bar{4}$	99$\bar{9}$	*01$\bar{4}$	*029	*044	*05$\bar{9}$	*07$\bar{5}$	
289	46 090	105	120	135	150	165	180	195	210	225	
290	240	255	26$\bar{9}$	28$\bar{4}$	29$\bar{9}$	31$\bar{4}$	32$\bar{9}$	34$\bar{4}$	35$\bar{9}$	37$\bar{4}$	14 14
											.1 1.4 1.4
291	38$\bar{9}$	404	419	434	44$\bar{9}$	46$\bar{4}$	479	49$\bar{3}$	50$\bar{8}$	52$\bar{3}$	.2 2.9 2.8
292	53$\bar{8}$	55$\bar{3}$	56$\bar{8}$	583	59$\bar{7}$	612	62$\bar{7}$	64$\bar{2}$	657	672	.3 4.3 4.2
293	68$\bar{7}$	70$\bar{1}$	71$\bar{6}$	731	746	761	77$\bar{5}$	790	805	820	.4 5.8 5.6
294	83$\bar{4}$	84$\bar{9}$	86$\bar{4}$	87$\bar{9}$	89$\bar{4}$	90$\bar{8}$	92$\bar{3}$	938	95$\bar{2}$	96$\bar{7}$	.5 7.2 7.0
295	982	997	*01$\bar{1}$	*02$\bar{6}$	*041	*05$\bar{5}$	*070	*08$\bar{5}$	*100	*11$\bar{4}$	.6 8.7 8.4
296	47 129	144	15$\bar{8}$	173	188	20$\bar{2}$	217	232	24$\bar{6}$	261	.7 10.1 9.8
297	27$\bar{5}$	290	305	31$\bar{9}$	334	34$\bar{8}$	36$\bar{3}$	378	39$\bar{2}$	407	.8 11.6 11.2
298	42$\bar{1}$	436	451	46$\bar{5}$	480	49$\bar{4}$	509	52$\bar{3}$	538	55$\bar{2}$	.9 13.0 12.6
299	567	58$\bar{1}$	596	610	625	639	654	66$\bar{8}$	683	697	
300	712	72$\bar{6}$	741	75$\bar{5}$	770	78$\bar{4}$	799	81$\bar{3}$	828	842	
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300	47 712	726	741	755	770	784	799	813	828	842
301		856	871	885	900	914	928	943	957	972	986
302	48 000	015	029	044	058	072	087	101	115	130
303		144	158	173	187	201	216	230	244	259	273
304		287	301	316	330	344	358	373	387	401	415
305		430	444	458	472	487	501	515	529	543	558
306		572	586	600	614	629	643	657	671	685	699
307		714	728	742	756	770	784	798	812	827	841
308		855	869	883	897	911	925	939	953	967	982
309		996	*010	*024	*038	*052	*066	*080	*094	*108	*122
310	49 136	150	164	178	192	206	220	234	248	262
311		276	290	304	318	332	346	359	373	387	401
312		415	429	443	457	471	485	499	513	526	540
313		554	568	582	596	610	624	637	651	665	679
314		693	707	720	734	748	762	776	789	803	817
315		831	845	858	872	886	900	913	927	941	955
316		968	982	996	*010	*023	*037	*051	*065	*078	*092
317	50 106	119	133	147	160	174	188	201	215	229
318		242	256	270	283	297	311	324	338	352	365
319		379	392	406	420	433	447	460	474	488	501
320		515	528	542	555	569	583	596	610	623	637
321		650	664	677	691	704	718	731	745	758	772
322		785	799	812	826	839	853	866	880	893	907
323		920	933	947	960	974	987	*001	*014	*027	*041
324	51 054	068	081	094	108	121	135	148	161	175
325		188	201	215	228	242	255	268	282	295	308
326		322	335	348	361	375	388	401	415	428	441
327		455	468	481	494	508	521	534	547	561	574
328		587	600	614	627	640	653	667	680	693	706
329		719	733	746	759	772	785	798	812	825	838
330		851	864	877	891	904	917	930	943	956	969
331		983	996	*009	*022	*035	*048	*061	*074	*087	*100
332	52 114	127	140	153	166	179	192	205	218	231
333		244	257	270	283	296	309	322	335	348	361
334		374	387	400	413	426	439	452	465	478	491
335		504	517	530	543	556	569	582	595	608	621
336		634	647	660	672	685	698	711	724	737	750
337		763	776	789	801	814	827	840	853	866	879
338		891	904	917	930	943	956	968	981	994	*007
339	53 020	033	045	058	071	084	097	109	122	135
340		148	160	173	186	199	211	224	237	250	262
341		275	288	301	313	326	339	352	364	377	390
342		402	415	428	440	453	466	478	491	504	516
343		529	542	554	567	580	592	605	618	630	643
344		656	668	681	693	706	719	731	744	756	769
345		782	794	807	819	832	845	857	870	882	895
346		907	920	932	945	958	970	983	995	*008	*020
347	54 033	045	058	070	083	095	108	120	133	145
348		158	170	183	195	208	220	232	245	257	270
349		282	295	307	320	332	344	357	369	382	394
350		407	419	431	444	456	469	481	493	506	518

P. P.		
	14	14
·1	1·4	1·4
·2	2·9	2·8
·3	4·3	4·2
·4	5·8	5·6
·5	7·2	7·0
·6	8·7	8·4
·7	10·1	9·8
·8	11·6	11·2
·9	13·0	12·6

P. P.		
	13	13
·1	1·3	1·3
·2	2·7	2·6
·3	4·0	3·9
·4	5·4	5·2
·5	6·7	6·5
·6	8·1	7·8
·7	9·4	9·1
·8	10·8	10·4
·9	12·1	11·7

P. P.		
	12	12
·1	1·2	1·2
·2	2·5	2·4
·3	3·7	3·6
·4	5·0	4·8
·5	6·2	6·0
·6	7·5	7·2
·7	8·7	8·4
·8	10·0	9·6
·9	11·2	10·8

N.	0	1	2	3	4	5	6	7	8	9	P. P.
350	54 407	419	431	444	456	469	481	493	506	518	
											12
351	530	543	555	568	580	592	605	617	629	642	.1 1.2
352	654	666	679	691	703	716	728	740	753	765	.2 2.5
353	777	790	802	814	826	839	851	863	876	888	.3 3.7
354	900	912	925	937	949	961	974	986	998	*010	.4 5.0
355	55 023	035	047	059	071	084	096	108	120	133	.5 6.2
356	145	157	169	181	194	206	218	230	242	254	.6 7.5
357	267	279	291	303	315	327	340	352	364	376	.7 8.7
358	388	400	412	424	437	449	461	473	485	497	.8 10.0
359	509	521	533	545	558	570	582	594	606	618	.9 11.2
360	630	642	654	666	678	690	702	714	726	738	
											12
361	750	762	775	787	799	811	823	835	847	859	1 1.2
362	871	883	895	907	919	931	943	955	966	978	2 2.4
363	990	*002	*014	*026	*038	*050	*062	*074	*086	*098	.3 3.6
364	56 110	122	134	146	158	170	181	193	205	217	.4 4.8
365	229	241	253	265	277	288	300	312	324	336	.5 6.0
366	348	360	372	383	395	407	419	431	443	455	.6 7.2
367	466	478	490	502	514	525	537	549	561	573	.7 8.4
368	585	596	608	620	632	643	655	667	679	691	.8 9.6
369	702	714	726	738	749	761	773	785	796	808	.9 10.8
370	820	832	843	855	867	879	890	902	914	925	
											11
371	937	949	961	972	984	996	*007	*019	*031	*042	.1 1.1
372	57 054	066	077	089	101	112	124	136	147	159	.2 2.3
373	171	182	194	206	217	229	240	252	264	275	.3 3.4
374	287	299	310	322	333	345	357	368	380	391	.4 4.6
375	403	414	426	438	449	461	472	484	495	507	.5 5.7
376	519	530	542	553	565	576	588	599	611	622	.6 6.9
377	634	645	657	668	680	691	703	714	726	737	.7 8.0
378	749	760	772	783	795	806	818	829	841	852	.8 9.2
379	864	875	887	898	909	921	932	944	955	967	.9 10.3
380	978	990	*001	*012	*024	*035	*047	*058	*069	*081	
											11
381	58 092	104	115	126	138	149	161	172	183	195	.1 1.1
382	206	217	229	240	252	263	274	286	297	308	.2 2.2
383	320	331	342	354	365	376	388	399	410	422	.3 3.3
384	433	444	455	467	478	489	501	512	523	535	.4 4.4
385	546	557	568	580	591	602	613	625	636	647	.5 5.5
386	658	670	681	692	703	715	726	737	748	760	.6 6.6
387	771	782	793	804	816	827	838	849	861	872	.7 7.7
388	883	894	905	916	928	939	950	961	972	984	.8 8.8
389	995	*006	*017	*028	*039	*050	*062	*073	*084	*095	.9 9.9
390	59 106	117	128	140	151	162	173	184	195	206	
											10
391	217	229	240	251	262	273	284	295	306	317	.1 1.0
392	328	339	351	362	373	384	395	406	417	428	.2 2.1
393	439	450	461	472	483	494	505	516	527	538	.3 3.1
394	549	560	571	582	593	604	615	626	637	648	.4 4.2
395	659	670	681	692	703	714	725	736	747	758	.5 5.2
396	769	780	791	802	813	824	835	846	857	868	.6 6.3
397	879	890	901	912	923	933	944	955	966	977	.7 7.3
398	988	999	*010	*021	*032	*043	*053	*064	*075	*086	.8 8.4
399	60 097	108	119	130	141	151	162	173	184	195	.9 9.4
400	208	217	227	238	249	260	271	282	293	303	

N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
400	60 206	217	227	238	249	260	271	282	293	303	
401	314	325	336	347	357	368	379	390	401	412	
402	422	433	444	455	466	476	487	498	509	519	
403	530	541	552	563	573	584	595	606	616	627	11
404	638	649	659	670	681	692	702	713	724	735	.1 | 1.1
405	745	756	767	777	785	799	810	820	831	842	.2 | 2.2
406	852	863	874	884	895	906	916	927	938	949	.3 | 3.3
407	959	970	981	991	*002	*013	*023	*034	*044	*055	.4 | 4.4
408	61 066	076	087	098	108	119	130	140	151	161	.5 | 5.5
409	172	183	193	204	215	225	236	246	257	268	.6 | 6.6
											.7 | 7.7
410	278	289	295	310	320	331	342	352	363	373	.8 | 8.8
											.9 | 9.9
411	384	394	405	416	426	437	447	458	468	479	
412	489	500	511	521	532	542	553	563	574	584	
413	595	605	616	626	637	647	658	668	679	689	
414	700	710	721	731	742	752	763	773	784	794	
415	805	815	825	836	846	857	867	878	888	899	10
416	909	920	930	940	951	961	972	982	993	*003	.1 | 1.0
417	62 013	024	034	045	055	065	076	086	097	107	.2 | 2.1
418	117	128	138	149	159	169	180	190	200	211	.3 | 3.1
419	221	232	242	252	263	273	283	294	304	314	.4 | 4.2
											.5 | 5.2
420	325	335	345	356	366	376	387	397	407	418	.6 | 6.3
											.7 | 7.3
421	428	438	449	459	469	480	490	500	510	521	.8 | 8.4
422	531	541	552	562	572	582	593	603	613	624	.9 | 9.4
423	634	644	654	665	675	685	695	706	716	726	
424	736	747	757	767	777	788	798	808	818	828	
425	839	849	859	869	879	890	900	910	920	931	
426	941	951	961	971	981	992	*002	*012	*022	*032	
427	63 043	053	063	073	083	093	104	114	124	134	10
428	144	154	164	175	185	195	205	215	225	235	.1 | 1.0
429	245	256	266	276	286	296	306	316	326	336	.2 | 2.0
											.3 | 3.0
430	347	357	367	377	387	397	407	417	427	437	.4 | 4.0
											.5 | 5.0
431	447	458	468	478	488	498	508	518	528	538	.6 | 6.0
432	548	558	568	578	588	598	608	618	628	639	.7 | 7.0
433	649	659	669	679	689	699	709	719	729	739	.8 | 8.0
434	749	759	769	779	789	799	809	819	829	839	.9 | 9.0
435	849	859	869	879	889	899	909	919	928	938	
436	948	958	968	978	988	998	*008	*018	*028	*038	
437	64 048	058	068	078	088	098	107	117	127	137	
438	147	157	167	177	187	197	207	217	226	236	
439	246	256	266	276	286	296	306	315	325	335	9
											.1 | 0.9
440	345	355	365	375	384	394	404	414	424	434	.2 | 1.9
											.3 | 2.8
441	444	453	463	473	483	493	503	512	522	532	.4 | 3.8
442	542	552	562	571	581	591	601	611	621	630	.5 | 4.7
443	640	650	660	670	679	689	699	709	718	728	.6 | 5.7
444	738	748	758	767	777	787	797	806	816	826	.7 | 6.6
445	836	846	855	865	875	885	894	904	914	923	.8 | 7.6
446	933	943	953	962	972	982	992	*001	*011	*021	.9 | 8.5
447	65 031	040	050	060	069	079	089	098	108	118	
448	128	137	147	157	166	176	186	195	205	215	
449	224	234	244	253	263	273	282	292	302	311	
450	321	331	340	350	360	369	379	389	398	408	

N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
450	65 321	331	340	350	360	369	379	389	398	408	
451	417	427	437	446	456	466	475	485	494	504	
452	514	523	533	542	552	562	571	581	590	600	10
453	610	619	629	638	648	657	667	677	686	696	.1 1.0
454	705	715	724	734	744	753	763	772	782	791	.2 2.0
455	801	810	820	830	839	849	858	868	877	887	.3 3.0
456	896	906	915	925	934	944	953	963	972	982	.4 4.0
457	991	*001	*010	*020	*029	*039	*048	*058	*067	*077	.5 5.0
458	66 086	096	105	115	124	134	143	153	162	172	.6 6.0
459	181	190	200	209	219	228	238	247	257	266	.7 7.0
											.8 8.0
460	276	285	294	304	313	323	332	342	351	360	.9 9.0
461	370	379	389	398	408	417	426	436	445	455	
462	464	473	483	492	502	511	520	530	539	548	
463	558	567	577	586	595	605	614	623	633	642	
464	652	661	670	680	689	698	708	717	726	736	
465	745	754	764	773	782	792	801	810	820	829	9
466	838	848	857	866	876	885	894	904	913	922	.1 0.9
467	931	941	950	959	969	978	987	996	*006	*015	.2 1.8
468	67 024	034	043	052	061	071	080	089	099	108	.3 2.7
469	117	126	136	145	154	163	173	182	191	200	.4 3.6
											.5 4.5
470	210	219	228	237	246	256	265	274	283	293	.6 5.4
471	302	311	320	329	339	348	357	366	376	385	.7 6.3
472	394	403	412	422	431	440	449	458	467	477	.8 7.2
473	486	495	504	513	523	532	541	550	559	568	.9 8.1
474	578	587	596	605	614	623	633	642	651	660	
475	669	678	687	697	706	715	724	733	742	751	
476	760	770	779	788	797	806	815	824	833	842	
477	852	861	870	879	888	897	906	915	924	933	
478	943	952	961	970	979	988	997	*006	*015	*024	
479	68 033	042	051	060	070	079	088	097	106	115	9
											.1 0.9
480	124	133	142	151	160	169	178	187	196	205	.2 1.8
											.3 2.7
481	214	223	232	241	250	259	268	277	286	295	.4 3.6
482	304	313	322	331	340	349	358	367	376	385	.5 4.5
483	394	403	412	421	430	439	448	457	466	475	.6 5.4
484	484	493	502	511	520	529	538	547	556	565	.7 6.3
485	574	583	592	601	610	619	628	637	646	654	.8 7.2
486	663	672	681	690	699	708	717	726	735	744	.9 8.1
487	753	762	770	779	788	797	806	815	824	833	
488	842	851	860	868	877	886	895	904	913	922	
489	931	940	948	957	966	975	984	993	*002	*010	
490	69 019	028	037	046	055	064	073	081	090	099	8
											.1 0.8
491	108	117	126	134	143	152	161	170	179	187	.2 1.6
492	196	205	214	223	232	240	249	258	267	276	.3 2.4
493	284	293	302	311	320	328	337	346	355	364	.4 3.2
494	372	381	390	399	408	416	425	434	443	451	.5 4.0
495	460	469	478	487	495	504	513	522	530	539	.6 4.8
496	548	557	565	574	583	592	600	609	618	627	.7 5.6
497	635	644	653	662	670	679	688	697	705	714	.8 6.4
498	723	731	740	749	758	766	775	784	792	801	.9 7.2
499	810	819	827	836	845	853	862	871	879	888	
500	897	905	914	923	931	940	949	958	966	975	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
500	69 897	905	914	923	931	940	949	958	966	975	
501	984	992	*001	*010	*018	*027	*036	*044	*053	*061	
502	70 070	079	087	096	105	113	122	131	139	148	9
503	157	165	174	182	191	200	208	217	226	234	.1 0.9
504	243	251	260	269	277	286	294	303	312	320	.2 1.8
505	329	337	346	355	363	372	380	389	398	406	.3 2.7
506	415	423	432	441	449	458	466	475	483	492	.4 3.6
507	501	509	518	526	535	543	552	560	569	578	.5 4.5
508	586	595	603	612	620	629	637	646	654	663	.6 5.4
509	672	680	689	697	706	714	723	731	740	748	.7 6.3
											.8 7.2
510	757	765	774	782	791	799	808	816	825	833	.9 8.1
511	842	850	859	867	876	884	893	901	910	918	
512	927	935	944	952	961	969	978	986	995	*003	
513	71 011	020	028	037	045	054	062	071	079	088	
514	096	105	113	121	130	138	147	155	164	172	
515	180	189	197	206	214	223	231	239	248	256	8
516	265	273	282	290	298	307	315	324	332	340	.1 0.8
517	349	357	366	374	382	391	399	408	416	424	.2 1.7
518	433	441	449	458	466	475	483	491	500	508	.3 2.5
519	516	525	533	542	550	558	567	575	583	592	.4 3.4
											.5 4.2
520	600	608	617	625	633	642	650	659	667	675	.6 5.1
											.7 5.9
521	684	692	700	709	717	725	734	742	750	758	.8 6.8
522	767	775	783	792	800	808	817	825	833	842	.9 7.6
523	850	858	867	875	883	891	900	908	916	925	
524	933	941	949	958	966	974	983	991	999	*007	
525	72 016	024	032	040	049	057	065	074	082	090	
526	098	107	115	123	131	140	148	156	164	173	
527	181	189	197	206	214	222	230	238	247	255	
528	263	271	280	288	296	304	312	321	329	337	8
529	345	354	362	370	378	386	395	403	411	419	.1 0.8
											.2 1.6
530	427	436	444	452	460	468	476	485	493	501	.3 2.4
											.4 3.2
531	509	517	526	534	542	550	558	566	575	583	.5 4.0
532	591	599	607	615	624	632	640	648	656	664	.6 4.8
533	672	681	689	697	705	713	721	729	738	746	.7 5.6
534	754	762	770	778	786	795	803	811	819	827	.8 6.4
535	835	843	851	859	868	876	884	892	900	908	.9 7.2
536	916	924	932	941	949	957	965	973	981	989	
537	997	*005	*013	*021	*030	*038	*046	*054	*062	*070	
538	73 078	086	094	102	110	118	126	134	143	151	
539	159	167	175	183	191	199	207	215	223	231	
540	239	247	255	263	271	279	287	295	303	311	7
											.1 0.7
541	319	328	336	344	352	360	368	376	384	392	.2 1.5
542	400	408	416	424	432	440	448	456	464	472	.3 2.2
543	480	488	496	504	512	520	528	536	544	552	.4 3.0
544	560	568	576	584	592	600	608	615	623	631	.5 3.7
545	639	647	655	663	671	679	687	695	703	711	.6 4.5
546	719	727	735	743	751	759	767	775	783	791	.7 5.2
547	798	806	814	822	830	838	846	854	862	870	.8 6 0
548	878	886	894	902	909	917	925	933	941	949	.9 6.7
549	957	965	973	981	989	997	*004	*012	*020	*028	
550	74 036	044	052	060	068	075	083	091	099	107	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
550	74 036	044	052	060	068	075	083	091	099	107	
551	115	123	131	139	146	154	162	170	178	186	
552	194	202	209	217	225	233	241	249	257	264	
553	272	280	288	296	304	312	319	327	335	343	
554	351	359	366	374	382	390	398	406	413	421	
555	429	437	445	453	460	468	476	484	492	499	
556	507	515	523	531	538	546	554	562	570	577	
557	585	593	601	609	616	624	632	640	648	655	8
558	663	671	679	687	694	702	710	718	725	733	.1 | 0.8
559	741	749	756	764	772	780	788	795	803	811	.2 | 1.6
560	819	826	834	842	850	857	865	873	881	888	.3 | 2.4
561	896	904	912	919	927	935	942	950	958	966	.4 | 3.2
562	973	981	989	997	*004	*012	*020	*027	*035	*043	.5 | 4.0
563	75 051	058	066	074	081	089	097	105	112	120	.6 | 4.8
564	128	135	143	151	158	166	174	182	189	197	.7 | 5.6
565	205	212	220	228	235	243	251	258	266	274	.8 | 6.4
566	281	289	297	304	312	320	327	335	343	350	.9 | 7.2
567	358	366	373	381	389	396	404	412	419	427	
568	435	442	450	458	465	473	480	488	496	503	
569	511	519	526	534	541	549	557	564	572	580	
570	587	595	602	610	618	625	633	641	648	656	
571	663	671	679	686	694	701	709	717	724	732	7
572	739	747	755	762	770	777	785	792	800	808	.1 | 0.7
573	815	823	830	838	846	853	861	868	876	883	.2 | 1.4
574	891	899	906	914	921	929	936	944	951	959	.3 | 2.1
575	967	974	982	989	997	*004	*012	*019	*027	*034	.4 | 2.8
576	76 042	050	057	065	072	080	087	095	102	110	.5 | 3.5
577	117	125	132	140	147	155	162	170	178	185	.6 | 4.2
578	193	200	208	215	223	230	238	245	253	260	.7 | 4.9
579	268	275	283	290	298	305	313	320	328	335	.8 | 5.6
580	343	350	358	365	372	380	387	395	402	410	.9 | 6.3
581	417	425	432	440	447	455	462	470	477	485	
582	492	500	507	514	522	529	537	544	552	559	
583	567	574	582	589	596	604	611	619	626	634	
584	641	648	656	663	671	678	686	693	700	708	
585	715	723	730	738	745	752	760	767	775	782	
586	790	797	804	812	819	827	834	841	849	856	
587	864	871	878	886	893	901	908	915	923	930	
588	937	945	952	960	967	974	982	989	997	*004	7
589	77 011	019	026	033	041	048	055	063	070	078	.1 | 0.7
590	085	092	100	107	114	122	129	136	144	151	.2 | 1.4
591	158	166	173	181	188	195	203	210	217	225	.3 | 2.1
592	232	239	247	254	261	269	276	283	291	298	.4 | 2.8
593	305	313	320	327	335	342	349	356	364	371	.5 | 3.5
594	378	386	393	400	408	415	422	430	437	444	.6 | 4.2
595	451	459	466	473	481	488	495	503	510	517	.7 | 4.9
596	524	532	539	546	554	561	568	575	583	590	.8 | 5.6
597	597	604	612	619	626	634	641	648	655	663	.9 | 6.3
598	670	677	684	692	699	706	713	721	728	735	
599	742	750	757	764	771	779	786	793	800	808	
600	815	822	829	837	844	851	858	866	873	880	
N.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**P. P.**

N.	0	1	2	3	4	5	6	7	8	9	P. P.
600	77 815	822	829	837	844	851	858	866	873	880	
601	887	894	902	909	916	923	931	938	945	952	
602	959	967	974	981	988	995	*003	*010	*017	*024	
603	78 031	039	046	053	060	067	075	082	089	096	
604	103	111	118	125	132	139	147	154	161	168	
605	175	182	190	197	204	211	218	226	233	240	
606	247	254	261	269	276	283	290	297	304	311	
607	319	326	333	340	347	354	362	369	376	383	
608	390	397	404	412	419	426	433	440	447	454	
609	461	469	476	483	490	497	504	511	518	526	
610	533	540	547	554	561	568	575	583	590	597	
611	604	611	618	625	632	639	646	654	661	668	
612	675	682	689	696	703	710	717	725	732	739	
613	746	753	760	767	774	781	788	795	802	810	
614	817	824	831	838	845	852	859	866	873	880	
615	887	894	901	908	915	923	930	937	944	951	
616	958	965	972	979	986	993	*000	*007	*014	*021	
617	79 028	035	042	049	056	063	070	078	085	092	
618	099	106	113	120	127	134	141	148	155	162	
619	169	176	183	190	197	204	211	218	225	232	
620	239	246	253	260	267	274	281	288	295	302	
621	309	316	323	330	337	344	351	358	365	372	
622	379	386	393	400	407	414	421	428	435	442	
623	449	456	462	469	476	483	490	497	504	511	
624	518	525	532	539	546	553	560	567	574	581	
625	588	595	602	609	616	622	629	636	643	650	
626	657	664	671	678	685	692	699	706	713	720	
627	727	733	740	747	754	761	768	775	782	789	
628	796	803	810	816	823	830	837	844	851	858	
629	865	872	879	886	892	899	906	913	920	927	
630	934	941	948	954	961	968	975	982	989	996	
631	80 003	010	016	023	030	037	044	051	058	065	
632	071	078	085	092	099	106	113	120	126	133	
633	140	147	154	161	168	174	181	188	195	202	
634	209	216	222	229	236	243	250	257	263	270	
635	277	284	291	298	304	311	318	325	332	339	
636	345	352	359	366	373	380	386	393	400	407	
637	414	421	427	434	441	448	455	461	468	475	
638	482	489	495	502	509	516	523	529	536	543	
639	550	557	563	570	577	584	591	597	604	611	
640	618	625	631	638	645	652	658	665	672	679	
641	686	692	699	706	713	719	726	733	740	746	
642	753	760	767	774	780	787	794	801	807	814	
643	821	828	834	841	848	855	861	868	875	882	
644	888	895	902	909	915	922	929	936	942	949	
645	956	962	969	976	983	989	996	*003	*010	*016	
646	81 023	030	036	043	050	057	063	070	077	083	
647	090	097	104	110	117	124	130	137	144	151	
648	157	164	171	177	184	191	197	204	211	218	
649	224	231	238	244	251	258	264	271	278	284	
650	291	298	304	311	318	324	331	338	345	351	

N.	0	1	2	3	4	5	6	7	8	9	P. P.

P. P.

	7
.1	0.7
.2	1.5
.3	2.2
.4	3.0
.5	3.7
.6	4.5
.7	5.2
.8	6.0
.9	6.7

P. P.

	7
.1	0.7
.2	1.4
.3	2.1
.4	2.8
.5	3.5
.6	4.2
.7	4.9
.8	5.6
.9	6.3

P. P.

	6
.1	0.6
.2	1.3
.3	1.9
.4	2.8
.5	3.2
.6	3.9
.7	4.5
.8	5.2
.9	5.8

N.	0	1	2	3	4	5	6	7	8	9	P. P.
650	81 29$\bar{1}$	298	30$\bar{4}$	31$\bar{1}$	318	32$\bar{4}$	33$\bar{1}$	338	345	35$\bar{1}$	
651	358	365	37$\bar{1}$	378	385	39$\bar{1}$	398	405	41$\bar{1}$	418	
652	425	43$\bar{1}$	438	444	45$\bar{1}$	458	46$\bar{4}$	47$\bar{1}$	478	484	
653	49$\bar{1}$	498	504	51$\bar{1}$	518	524	531	538	54$\bar{4}$	551	
654	558	56$\bar{4}$	571	577	58$\bar{4}$	591	59$\bar{7}$	604	611	617	
655	624	631	63$\bar{7}$	644	650	65$\bar{7}$	664	670	677	684	
656	690	697	703	710	717	72$\bar{3}$	730	736	74$\bar{3}$	750	
657	75$\bar{6}$	763	770	776	783	789	796	803	809	816	7
658	82$\bar{2}$	829	836	84$\bar{2}$	849	85$\bar{5}$	862	869	87$\bar{5}$	882	.1 | 0.7
659	88$\bar{8}$	895	901	908	915	92$\bar{1}$	928	93$\bar{4}$	941	948	.2 | 1.4
											.3 | 2.1
660	95$\bar{4}$	961	96$\bar{7}$	974	980	98$\bar{7}$	994	*000	*007	*013	.4 | 2.8
											.5 | 3.5
661	82 020	02$\bar{6}$	03$\bar{3}$	040	04$\bar{0}$	05$\bar{3}$	05$\bar{9}$	06$\bar{6}$	07$\bar{2}$	079	.6 | 4.2
662	08$\bar{6}$	09$\bar{2}$	099	105	112	118	125	13$\bar{1}$	138	145	.7 | 4.9
663	15$\bar{1}$	158	16$\bar{4}$	171	17$\bar{7}$	184	190	197	20$\bar{3}$	21$\bar{0}$	.8 | 5.6
664	217	22$\bar{3}$	230	23$\bar{6}$	24$\bar{3}$	249	25$\bar{6}$	26$\bar{2}$	269	275	.9 | 6.3
665	28$\bar{2}$	28$\bar{8}$	295	302	30$\bar{8}$	315	32$\bar{1}$	328	33$\bar{4}$	341	
666	34$\bar{7}$	354	36$\bar{0}$	367	37$\bar{3}$	380	38$\bar{6}$	393	39$\bar{9}$	406	
667	41$\bar{2}$	419	42$\bar{5}$	432	43$\bar{8}$	445	45$\bar{1}$	458	46$\bar{4}$	471	
668	47$\bar{7}$	484	49$\bar{0}$	497	503	510	51$\bar{6}$	523	52$\bar{9}$	536	
669	54$\bar{2}$	549	555	562	568	575	58$\bar{1}$	588	59$\bar{4}$	601	
670	60$\bar{7}$	614	62$\bar{0}$	627	63$\bar{3}$	640	64$\bar{6}$	653	65$\bar{9}$	666	
671	67$\bar{2}$	67$\bar{8}$	685	69$\bar{1}$	698	70$\bar{4}$	711	71$\bar{7}$	72$\bar{4}$	73$\bar{0}$	6
672	73$\bar{7}$	743	750	756	763	769	77$\bar{5}$	782	788	795	.1 | 0.6
673	80$\bar{1}$	808	81$\bar{4}$	821	82$\bar{7}$	834	840	84$\bar{6}$	853	85$\bar{9}$	.2 | 1.2
674	86$\bar{6}$	87$\bar{2}$	879	88$\bar{5}$	892	898	90$\bar{4}$	911	91$\bar{7}$	924	.3 | 1.8
675	93$\bar{0}$	937	943	94$\bar{9}$	956	96$\bar{2}$	969	97$\bar{5}$	982	988	.4 | 2.6
676	99$\bar{4}$	*001	*007	*014	*020	*027	*033	*03$\bar{9}$	*046	*052	.5 | 3.2
677	83 059	06$\bar{5}$	071	078	08$\bar{4}$	091	097	10$\bar{3}$	110	11$\bar{6}$	.6 | 3.9
678	123	12$\bar{9}$	136	142	14$\bar{8}$	155	16$\bar{1}$	16$\bar{8}$	174	18$\bar{0}$	.7 | 4.5
679	187	19$\bar{3}$	200	206	21$\bar{2}$	219	22$\bar{5}$	23$\bar{1}$	238	24$\bar{4}$	.8 | 5.2
											.9 | 5.8
680	251	25$\bar{7}$	26$\bar{3}$	270	27$\bar{6}$	283	289	29$\bar{5}$	302	30$\bar{8}$	
681	31$\bar{4}$	321	32$\bar{7}$	33$\bar{4}$	340	34$\bar{6}$	35$\bar{3}$	35$\bar{9}$	36$\bar{5}$	372	
682	37$\bar{8}$	38$\bar{5}$	391	39$\bar{7}$	40$\bar{4}$	41$\bar{0}$	41$\bar{6}$	423	42$\bar{9}$	43$\bar{5}$	
683	44$\bar{2}$	44$\bar{8}$	45$\bar{5}$	46$\bar{1}$	46$\bar{7}$	47$\bar{4}$	480	48$\bar{6}$	49$\bar{3}$	49$\bar{9}$	
684	50$\bar{5}$	51$\bar{2}$	51$\bar{8}$	52$\bar{4}$	53$\bar{1}$	53$\bar{7}$	54$\bar{3}$	550	55$\bar{6}$	56$\bar{2}$	
685	56$\bar{9}$	57$\bar{5}$	58$\bar{1}$	58$\bar{8}$	59$\bar{4}$	600	607	61$\bar{3}$	61$\bar{9}$	626	
686	63$\bar{2}$	63$\bar{8}$	645	65$\bar{1}$	65$\bar{7}$	664	67$\bar{0}$	67$\bar{6}$	683	68$\bar{9}$	
687	69$\bar{5}$	702	70$\bar{8}$	71$\bar{4}$	721	72$\bar{7}$	73$\bar{3}$	740	746	75$\bar{2}$	6
688	759	765	77$\bar{1}$	778	784	79$\bar{0}$	79$\bar{6}$	803	80$\bar{9}$	81$\bar{5}$	.1 | 0.6
689	822	828	83$\bar{4}$	841	847	85$\bar{3}$	85$\bar{9}$	866	87$\bar{2}$	87$\bar{8}$	.2 | 1.2
											.3 | 1.8
690	885	891	89$\bar{7}$	904	910	91$\bar{6}$	92$\bar{2}$	929	935	94$\bar{1}$	.4 | 2.4
											.5 | 3.0
691	948	954	96$\bar{0}$	96$\bar{6}$	973	979	98$\bar{5}$	992	998	*00$\bar{4}$	.6 | 3.6
692	84 01$\bar{0}$	017	023	02$\bar{9}$	03$\bar{5}$	042	048	05$\bar{4}$	061	067	.7 | 4.2
393	07$\bar{3}$	07$\bar{9}$	08$\bar{6}$	092	09$\bar{8}$	10$\bar{4}$	111	117	12$\bar{3}$	12$\bar{9}$	.8 | 4.8
694	13$\bar{6}$	14$\bar{2}$	14$\bar{8}$	15$\bar{4}$	161	167	17$\bar{3}$	17$\bar{9}$	18$\bar{6}$	192	.9 | 5.4
695	198	20$\bar{4}$	211	217	22$\bar{3}$	229	236	242	24$\bar{8}$	25$\bar{4}$	
696	26$\bar{1}$	26$\bar{7}$	27$\bar{3}$	279	286	29$\bar{2}$	29$\bar{8}$	30$\bar{4}$	311	317	
697	32$\bar{3}$	32$\bar{9}$	33$\bar{5}$	342	348	35$\bar{4}$	36$\bar{0}$	367	37$\bar{3}$	37$\bar{9}$	
698	38$\bar{5}$	392	398	40$\bar{4}$	41$\bar{0}$	41$\bar{6}$	423	429	43$\bar{5}$	44$\bar{1}$	
699	44$\bar{7}$	454	460	46$\bar{6}$	47$\bar{2}$	479	485	491	49$\bar{7}$	50$\bar{3}$	
700	510	516	522	52$\bar{8}$	53$\bar{4}$	541	547	553	55$\bar{9}$	56$\bar{5}$	

N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
700	84 510	516	522	528	534	541	547	553	559	565	
701	572	578	584	590	596	603	609	615	621	627	
702	633	640	646	652	658	664	671	677	683	689	
703	695	701	708	714	720	726	732	739	745	751	
704	757	763	769	776	782	788	794	800	806	813	
705	819	825	831	837	843	849	856	862	868	874	
706	880	886	893	899	905	911	917	923	929	936	
707	942	948	954	960	966	972	979	985	991	997	$\overline{6}$
708	85 003	009	015	021	028	034	040	046	052	058	·1 | 0.6
709	064	070	077	083	089	095	101	107	113	119	·2 | 1.3
											·3 | 1.9
710	126	132	138	144	150	156	162	168	174	181	·4 | 2.6
											·5 | 3.2
711	187	193	199	205	211	217	223	229	236	242	·6 | 3.9
712	248	254	260	266	272	278	284	290	297	303	·7 | 4.5
713	309	315	321	327	333	339	345	351	357	363	·8 | 5.2
714	370	376	382	388	394	400	406	412	418	424	·9 | 5.8
715	430	436	443	449	455	461	467	473	479	485	
716	491	497	503	509	515	521	527	533	540	546	
717	552	558	564	570	576	582	588	594	600	606	
718	612	618	624	630	636	642	648	655	661	667	
719	673	679	685	691	697	703	709	715	721	727	
720	733	739	745	751	757	763	769	775	781	787	
721	793	799	805	811	817	823	829	835	841	847	6
722	853	859	865	872	878	884	890	896	902	908	·1 | 0.6
723	914	920	926	932	938	944	950	956	962	968	·2 | 1.2
724	974	980	986	992	998	*004	*010	*016	*022	*028	·3 | 1.8
725	86 034	040	046	052	058	063	069	075	081	087	·4 | 2.4
726	093	099	105	111	117	123	129	135	141	147	·5 | 3.0
727	153	159	165	171	177	183	189	195	201	207	·6 | 3.6
728	213	219	225	231	237	243	249	255	261	267	·7 | 4.2
729	273	278	284	290	296	302	308	314	320	326	·8 | 4.8
											·9 | 5.4
730	332	338	344	350	356	362	368	374	380	386	
731	391	397	403	409	415	421	427	433	439	445	
732	451	457	463	469	475	481	486	492	498	504	
733	510	516	522	528	534	540	546	552	558	563	
734	569	575	581	587	593	599	605	611	617	623	
735	628	634	640	646	652	658	664	670	676	682	
736	688	693	699	705	711	717	723	729	735	741	
737	746	752	758	764	770	776	782	788	794	800	$\overline{5}$
738	805	811	817	823	829	835	841	847	852	858	·1 | 0.5
739	864	870	876	882	888	894	899	905	911	917	·2 | 1.1
											·3 | 1.6
740	923	929	935	941	946	952	958	964	970	976	·4 | 2.2
											·5 | 2.7
741	982	987	993	999	*005	*011	*017	*023	*028	*034	·6 | 3.3
742	87 040	046	052	058	064	069	075	081	087	093	·7 | 3.8
743	099	104	110	116	122	128	134	140	145	151	·8 | 4.4
744	157	163	169	175	180	186	192	198	204	210	·9 | 4.9
745	215	221	227	233	239	245	250	256	262	268	
746	274	279	285	291	297	303	309	314	320	326	
747	332	338	343	349	355	361	367	372	378	384	
748	390	396	402	407	413	419	425	431	436	442	
749	448	454	460	465	471	477	483	489	494	500	
750	506	512	517	523	529	535	541	546	552	558	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
750	87 506	512	517	523	529	535	541	546	552	558	
751	564	570	575	581	587	593	598	604	610	616	
752	622	627	633	639	645	650	656	662	668	673	
753	679	685	691	697	702	708	714	720	725	731	
754	737	743	748	754	760	766	771	777	783	789	
755	794	800	806	812	817	823	829	835	840	846	
756	852	858	863	869	875	881	886	892	898	904	
757	909	915	921	927	932	938	944	949	955	961	
758	967	972	978	984	990	995	*001	*007	*012	*018	6
759	88 024	030	035	041	047	053	058	064	070	075	·1 | 0·6
760	081	087	093	098	104	110	115	121	127	133	·2 | 1·2
761	138	144	150	155	161	167	172	178	184	190	·3 | 1·8
762	195	201	207	212	218	224	229	235	241	247	·4 | 2·4
763	252	258	264	269	275	281	286	292	298	303	·5 | 3·0
764	309	315	320	326	332	337	343	349	355	360	·6 | 3·6
765	366	372	377	383	389	394	400	406	411	417	·7 | 4·2
766	423	428	434	440	445	451	457	462	468	474	·8 | 4·8
767	479	485	491	496	502	508	513	519	525	530	·9 | 5·4
768	536	542	547	553	558	564	570	575	581	587	
769	592	598	604	609	615	621	626	632	638	643	
770	649	654	660	666	671	677	683	688	694	700	
771	705	711	716	722	728	733	739	745	750	756	5
772	761	767	773	778	784	790	795	801	806	812	·1 | 0·5
773	818	823	829	835	840	846	851	857	863	868	·2 | 1·1
774	874	879	885	891	896	902	907	913	919	924	·3 | 1·6
775	930	936	941	947	952	958	964	969	975	980	·4 | 2·2
776	986	992	997	*003	*008	*014	*019	*025	*031	*036	·5 | 2·7
777	89 042	047	053	059	064	070	075	081	087	092	·6 | 3·3
778	098	103	109	114	120	126	131	137	142	148	·7 | 3·8
779	153	159	165	170	176	181	187	193	198	204	·8 | 4·4
780	209	215	220	226	231	237	243	248	254	259	·9 | 4·9
781	265	270	276	282	287	293	298	304	309	315	
782	320	326	332	337	343	348	354	359	365	370	
783	376	381	387	393	398	404	409	415	420	426	
784	431	437	442	448	454	459	465	470	476	481	
785	487	492	498	503	509	514	520	525	531	536	
786	542	548	553	559	564	570	575	581	586	592	
787	597	603	608	614	619	625	630	636	641	647	5
788	652	658	663	669	674	680	685	691	696	702	·1 | 0·5
789	707	713	718	724	729	735	740	746	751	757	·2 | 1·0
790	762	768	773	779	784	790	795	801	806	812	·3 | 1·5
791	817	823	828	834	839	845	850	856	861	867	·4 | 2·0
792	872	878	883	889	894	900	905	911	916	922	·5 | 2·5
793	927	933	938	943	949	954	960	965	971	976	·6 | 3·0
794	982	987	993	998	*004	*009	*015	*020	*026	*031	·7 | 3·5
795	90 036	042	047	053	058	064	069	075	080	086	·8 | 4·0
796	091	097	102	107	113	118	124	129	135	140	·9 | 4·5
797	146	151	156	162	167	173	178	184	189	195	
798	200	205	211	216	222	227	233	238	244	249	
799	254	260	265	271	276	282	287	292	298	303	
800	309	314	320	325	330	336	341	347	352	358	

N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
800	90 309	314	320	325	330	336	341	347	352	358	
801	363	368	374	379	385	390	396	401	406	412	
802	417	423	428	433	439	444	450	455	460	466	
803	471	477	482	488	493	498	504	509	515	520	
804	525	531	536	542	547	552	558	563	569	574	
805	579	585	590	596	601	606	612	617	622	628	
806	633	639	644	649	655	660	666	671	676	682	
807	687	692	698	703	709	714	719	725	730	736	
808	741	746	752	757	762	768	773	778	784	789	
809	795	800	805	811	816	821	827	832	838	843	
810	848	854	859	864	870	875	880	886	891	896	
811	902	907	913	918	923	929	934	939	945	950	5
812	955	961	966	971	977	982	987	993	998	*003	·1 | 0.5
813	91 009	014	019	025	030	036	041	046	052	057	·2 | 1.1
814	062	068	073	078	084	089	094	100	105	110	·3 | 1.6
815	116	121	126	131	137	142	147	153	158	163	·4 | 2.2
816	169	174	179	185	190	195	201	206	211	217	·5 | 2.7
817	222	227	233	238	243	249	254	259	264	270	·6 | 3.3
818	275	280	286	291	296	302	307	312	318	323	·7 | 3.8
819	328	333	339	344	349	355	360	365	371	376	·8 | 4.4
											·9 | 4.9
820	381	386	392	397	402	408	413	418	423	429	
821	434	439	445	450	455	461	466	471	476	482	
822	487	492	497	503	508	513	519	524	529	534	
823	540	545	550	556	561	566	571	577	582	587	
824	592	598	603	608	614	619	624	629	635	640	
825	645	650	656	661	666	671	677	682	687	692	
826	698	703	708	714	719	724	729	735	740	745	
827	750	756	761	766	771	777	782	787	792	798	
828	803	808	813	819	824	829	834	839	845	850	
829	855	860	866	871	876	881	887	892	897	902	
830	908	913	918	923	928	934	939	944	949	955	
831	960	965	970	976	981	986	991	996	*002	*007	5
832	92 012	017	023	028	033	038	043	049	054	059	·1 | 0.5
833	064	069	075	080	085	090	096	101	106	111	·2 | 1.0
834	116	122	127	132	137	142	148	153	158	163	·3 | 1.5
835	168	174	179	184	189	194	200	205	210	215	·4 | 2.0
836	220	226	231	236	241	246	252	257	262	267	·5 | 2.5
837	272	277	283	288	293	298	303	309	314	319	·6 | 3.0
838	324	329	335	340	345	350	355	360	366	371	·7 | 3.5
839	376	381	386	391	397	402	407	412	417	423	·8 | 4.0
											·9 | 4.5
840	428	433	438	443	448	454	459	464	469	474	
841	479	485	490	495	500	505	510	515	521	526	
842	531	536	541	546	552	557	562	567	572	577	
843	583	588	593	598	603	608	613	619	624	629	
844	634	639	644	649	655	660	665	670	675	680	
845	685	691	696	701	706	711	716	721	727	732	
846	737	742	747	752	757	762	768	773	778	783	
847	788	793	798	803	809	814	819	824	829	834	
848	839	844	850	855	860	865	870	875	880	885	
849	891	896	901	906	911	916	921	926	931	937	
850	942	947	952	957	962	967	972	977	982	988	

N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
850	92 942	947	952	957	962	967	972	977	982	988	
851	993	998	*003	*008	*013	*018	*023	*028	*034	*039	
852	93 044	049	054	059	064	069	074	079	084	090	
853	095	100	105	110	115	120	125	130	135	140	
854	146	151	156	161	166	171	176	181	186	191	
855	196	201	207	212	217	222	227	232	237	242	
856	247	252	257	262	267	272	278	283	288	293	
857	298	303	308	313	318	323	328	333	338	343	5
858	348	354	359	364	369	374	379	384	389	394	.1 | 0.5
859	399	404	409	414	419	424	429	434	439	445	.2 | 1.1
											.3 | 1.6
860	450	455	460	465	470	475	480	485	490	495	.4 | 2.2
											.5 | 2.7
861	500	505	510	515	520	525	530	535	540	545	.6 | 3.3
862	550	556	561	566	571	576	581	586	591	596	.7 | 3.8
863	601	606	611	616	621	626	631	636	641	646	.8 | 4.4
864	651	656	661	666	671	676	681	686	691	696	.9 | 4.9
865	701	706	711	716	721	726	731	736	742	747	
866	752	757	762	767	772	777	782	787	792	797	
867	802	807	812	817	822	827	832	837	842	847	
868	852	857	862	867	872	877	882	887	892	897	
869	902	907	912	917	922	927	932	937	942	947	
870	952	957	962	967	972	977	982	987	992	997	
											5
871	94 002	007	012	017	022	026	031	036	041	046	.1 | 0.5
872	051	056	061	066	071	076	081	086	091	096	.2 | 1.0
873	101	106	111	116	121	126	131	136	141	146	.3 | 1.5
874	151	156	161	166	171	176	181	186	191	196	.4 | 2.0
875	201	206	210	215	220	225	230	235	240	245	.5 | 2.5
876	250	255	260	265	270	275	280	285	290	295	.6 | 3.0
877	300	305	310	315	320	324	329	334	339	344	.7 | 3.5
878	349	354	359	364	369	374	379	384	389	394	.8 | 4.0
879	399	404	409	413	418	423	428	433	438	443	.9 | 4.5
880	448	453	458	463	468	473	478	483	487	492	
881	497	502	507	512	517	522	527	532	537	542	
882	547	552	556	561	566	571	576	581	586	591	
883	596	601	606	611	615	620	625	630	635	640	
884	645	650	655	660	665	670	674	679	684	689	
885	694	699	704	709	714	719	724	728	733	738	
886	743	748	753	758	763	768	773	777	782	787	
887	792	797	802	807	812	817	821	826	831	836	4
888	841	846	851	856	861	865	870	875	880	885	.1 | 0.4
889	890	895	900	905	909	914	919	924	929	934	.2 | 0.9
											.3 | 1.3
890	939	944	949	953	958	963	968	973	978	983	.4 | 1.8
											.5 | 2.2
891	988	992	997	*002	*007	*012	*017	*022	*026	031	.6 | 2.7
892	95 036	041	046	051	056	061	065	070	075	080	.7 | 3.1
893	085	090	095	099	104	109	114	119	124	129	.8 | 3.6
894	134	138	143	148	153	158	163	167	172	177	.9 | 4.0
895	182	187	192	197	201	206	211	216	221	226	
896	231	235	240	245	250	255	260	264	269	274	
897	279	284	289	294	298	303	308	313	318	323	
898	327	332	337	342	347	352	356	361	366	371	
899	376	381	385	390	395	400	405	410	414	419	
900	424	429	434	438	443	448	453	458	463	467	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
900	95 424	429	434	438	443	448	453	458	463	467	
901	472	477	482	487	492	496	501	506	511	516	
902	520	525	530	535	540	544	549	554	559	564	
903	569	573	578	583	588	593	597	602	607	612	
904	617	621	626	631	636	641	645	650	655	660	
905	665	669	674	679	684	689	693	698	703	708	
906	713	717	722	727	732	737	741	746	751	756	
907	760	765	770	775	780	784	789	794	799	804	
908	808	813	818	823	827	832	837	842	847	851	
909	856	861	866	870	875	880	885	890	894	899	
910	904	909	913	918	923	928	933	937	942	947	
911	952	956	961	966	971	975	980	985	990	994	5
912	999	*004	*009	*014	*018	*023	*028	*033	*037	*042	.1 | 0.5
913	98 047	052	056	061	066	071	075	080	085	090	.2 | 1.0
914	094	099	104	109	113	118	123	128	132	137	.3 | 1.5
915	142	147	151	156	161	166	170	175	180	185	.4 | 2.0
916	189	194	199	204	208	213	218	222	227	232	.5 | 2.5
917	237	241	246	251	256	260	265	270	275	275	.6 | 3.0
918	284	289	293	298	303	308	312	317	322	327	.7 | 3.5
919	331	336	341	345	350	355	360	364	369	374	.8 | 4.0
											.9 | 4.5
920	379	383	388	393	397	402	407	412	416	421	
921	426	430	435	440	445	449	454	459	463	468	
922	473	478	482	487	492	496	501	506	511	515	
923	520	525	529	534	539	543	548	553	558	562	
924	567	572	576	581	586	590	595	600	605	609	
925	614	619	623	628	633	637	642	647	651	656	
926	661	666	670	675	680	684	689	694	698	703	
927	708	712	717	722	726	731	736	741	745	750	
928	755	759	764	769	773	778	783	787	792	797	
929	801	806	811	815	820	825	829	834	839	843	
930	848	853	857	862	867	871	876	881	885	890	
931	895	899	904	909	913	918	923	927	932	937	4
932	941	946	951	955	960	965	969	974	979	983	.1 | 0.4
933	988	993	997	*002	*007	*011	*016	*020	*025	*030	.2 | 0.8
934	97 034	039	044	048	053	058	062	067	072	076	.3 | 1.2
935	081	086	090	095	099	104	109	113	118	123	.4 | 1.6
936	127	132	137	141	146	151	155	160	164	169	.5 | 2.0
937	174	178	183	188	192	197	202	206	211	215	.6 | 2.4
938	220	225	229	234	239	243	248	252	257	262	.7 | 2.8
939	266	271	276	280	285	289	294	299	303	308	.8 | 3.2
											.9 | 3.6
940	313	317	322	326	331	336	340	345	349	354	
941	359	363	368	373	377	382	386	391	396	400	
942	405	409	414	419	423	428	432	437	442	446	
943	451	456	460	465	469	474	479	483	488	492	
944	497	502	506	511	515	520	525	529	534	538	
945	543	548	552	557	561	566	570	575	580	584	
946	589	593	598	603	607	612	616	621	626	630	
947	635	639	644	649	653	658	662	667	671	676	
948	681	685	690	694	699	703	708	713	717	722	
949	726	731	736	740	745	749	754	758	763	768	
950	772	777	781	786	790	795	800	804	809	813	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
950	97 772$\bar{6}$	777	781$\bar{1}$	786	790$\bar{5}$	795	800	804$\bar{4}$	809	813$\bar{3}$	
951	818	822$\bar{2}$	827	831$\bar{1}$	836$\bar{6}$	841	845$\bar{5}$	850	854$\bar{4}$	859	
952	863$\bar{3}$	868$\bar{8}$	873	877$\bar{7}$	882	886$\bar{6}$	891	895$\bar{5}$	900	904$\bar{4}$	
953	909$\bar{3}$	914$\bar{2}$	918$\bar{8}$	923	927$\bar{7}$	932	936$\bar{6}$	941	945$\bar{5}$	950$\bar{0}$	
954	955	959$\bar{9}$	964$\bar{4}$	968	973	977$\bar{7}$	982	986$\bar{6}$	991	996	
955	98 000	005	009$\bar{9}$	014	018$\bar{8}$	023	027$\bar{7}$	032	036$\bar{6}$	041	
956	046	050$\bar{0}$	055$\bar{5}$	059$\bar{9}$	064$\bar{4}$	068$\bar{8}$	073	077$\bar{7}$	082	086$\bar{6}$	
957	091	095	100$\bar{0}$	105	109$\bar{9}$	114	118$\bar{8}$	123	127$\bar{7}$	132	
958	136$\bar{6}$	141	145$\bar{5}$	150	154$\bar{4}$	159	163$\bar{3}$	168$\bar{8}$	173	177$\bar{7}$	5
959	182	186$\bar{6}$	191	195$\bar{5}$	200	204$\bar{4}$	209	213$\bar{3}$	218	222$\bar{2}$	·1 | 0.5
											·2 | 1.0
960	227	231$\bar{1}$	236	240$\bar{0}$	245	249$\bar{9}$	254$\bar{4}$	259	263$\bar{3}$	268	·3 | 1.5
											·4 | 2.0
961	272$\bar{2}$	277	281$\bar{1}$	286	290$\bar{0}$	295	299$\bar{9}$	304	308$\bar{8}$	313	·5 | 2.5
962	317$\bar{7}$	322	326$\bar{6}$	331	335$\bar{5}$	340	344$\bar{4}$	349	353$\bar{3}$	358	·6 | 3.0
963	362$\bar{2}$	367	371$\bar{1}$	376	380$\bar{0}$	385	389$\bar{9}$	394	398$\bar{8}$	403	·7 | 3.5
964	407$\bar{7}$	412	416$\bar{6}$	421	425$\bar{5}$	430	434$\bar{4}$	439	443$\bar{3}$	448	·8 | 4.0
965	452$\bar{2}$	457	461$\bar{1}$	466	470$\bar{0}$	475	479$\bar{9}$	484	488$\bar{8}$	493	·9 | 4.5
966	497$\bar{7}$	502	506$\bar{6}$	511	515$\bar{5}$	520	524$\bar{4}$	529	533$\bar{3}$	538	
967	542$\bar{2}$	547	551$\bar{1}$	556	560$\bar{0}$	565	569$\bar{9}$	574	578$\bar{8}$	583	
968	587$\bar{7}$	592	596$\bar{6}$	601	605$\bar{5}$	610	614$\bar{4}$	619	623$\bar{3}$	628	
969	632$\bar{2}$	637	641$\bar{1}$	646	650$\bar{0}$	655	659$\bar{9}$	663$\bar{3}$	668	672$\bar{2}$	
970	677	681$\bar{1}$	686	690$\bar{0}$	695	699$\bar{9}$	704	708$\bar{8}$	713	717$\bar{7}$	
971	722$\bar{2}$	726$\bar{6}$	731	735$\bar{5}$	740	744$\bar{4}$	749	753	757$\bar{7}$	762	4
972	766$\bar{6}$	771	775	780	784$\bar{4}$	789	793	798	802	807	·1 | 0.4
973	811$\bar{1}$	815$\bar{5}$	820	824$\bar{4}$	829	833$\bar{3}$	838	842$\bar{2}$	847	851$\bar{1}$	·2 | 0.8
974	856	860$\bar{0}$	865	869$\bar{9}$	873	878	882$\bar{2}$	887	891$\bar{1}$	896	·3 | 1.2
975	900$\bar{0}$	905	909$\bar{9}$	914	918$\bar{8}$	922$\bar{2}$	927	931$\bar{1}$	936	940$\bar{0}$	·4 | 1.6
976	945	949$\bar{9}$	954	958$\bar{8}$	963	967	971$\bar{1}$	976	980$\bar{0}$	985	·5 | 2.0
977	989	994	998	*003	*007	*011	*016	*020	*025	*029	·6 | 2.4
978	99 034	038$\bar{8}$	043	047	051$\bar{1}$	056	060	065	069$\bar{9}$	074	·7 | 2.8
979	078	082$\bar{2}$	087	091$\bar{1}$	096	100$\bar{0}$	105	109	113$\bar{3}$	118	·8 | 3.2
											·9 | 3.6
980	122$\bar{2}$	127	131$\bar{1}$	136	140$\bar{0}$	145	149	153$\bar{3}$	158	162$\bar{2}$	
981	167	171$\bar{1}$	176	180	184$\bar{4}$	189	193$\bar{3}$	198	202$\bar{2}$	206$\bar{6}$	
982	211	215$\bar{5}$	220	224$\bar{4}$	229	233$\bar{3}$	237	242	246$\bar{6}$	251	
983	255$\bar{5}$	260	264$\bar{4}$	268$\bar{8}$	273	277$\bar{7}$	282	286$\bar{6}$	290	295	
984	299$\bar{9}$	304	308$\bar{8}$	312$\bar{2}$	317	321$\bar{1}$	326	330$\bar{0}$	335	339	
985	343$\bar{3}$	348	352$\bar{2}$	357	361$\bar{1}$	365$\bar{5}$	370	374$\bar{4}$	379	383$\bar{3}$	
986	387$\bar{7}$	392	396$\bar{6}$	401	405$\bar{5}$	409$\bar{9}$	414	418$\bar{8}$	423	427$\bar{7}$	
987	431$\bar{1}$	436	440$\bar{0}$	445	449$\bar{9}$	453$\bar{3}$	458	462$\bar{2}$	467	471$\bar{1}$	4
988	475$\bar{5}$	480	484$\bar{4}$	489	493$\bar{3}$	497$\bar{7}$	502	506$\bar{6}$	511	515	·1 | 0.4
989	519	524	528	533	537	541$\bar{1}$	546	550$\bar{0}$	554$\bar{4}$	559	·2 | 0.8
											·3 | 1.2
990	563$\bar{3}$	568	572$\bar{2}$	576$\bar{6}$	581	585$\bar{5}$	590	594	598$\bar{8}$	603	·4 | 1.6
											·5 | 2.0
991	607$\bar{7}$	611$\bar{1}$	616	620$\bar{0}$	625	629$\bar{9}$	633$\bar{3}$	638	642$\bar{2}$	647	·6 | 2.4
992	651	655$\bar{5}$	660	664$\bar{4}$	668$\bar{8}$	673	677$\bar{7}$	682	686	690$\bar{0}$	·7 | 2.8
993	695$\bar{5}$	699$\bar{9}$	703$\bar{3}$	708	712$\bar{2}$	717$\bar{7}$	721	725$\bar{5}$	730	734$\bar{4}$	·8 | 3.2
994	738$\bar{8}$	743	747$\bar{7}$	751$\bar{1}$	756	760$\bar{6}$	765	769	773$\bar{3}$	778	·9 | 3.6
995	782$\bar{2}$	786$\bar{6}$	791	795$\bar{5}$	800	804$\bar{4}$	808$\bar{8}$	813	817	821$\bar{1}$	
996	826$\bar{8}$	830$\bar{0}$	834$\bar{4}$	839	843$\bar{3}$	847$\bar{7}$	852	856$\bar{6}$	861	865	
997	869$\bar{9}$	874$\bar{4}$	878	882$\bar{2}$	887	891$\bar{1}$	895$\bar{5}$	900	904$\bar{4}$	908$\bar{8}$	
998	913	917$\bar{7}$	922	926	930$\bar{0}$	935	939	943$\bar{3}$	948	952	
999	956	961	965	969	974	978$\bar{8}$	982$\bar{2}$	987	991$\bar{1}$	995$\bar{5}$	
1000	00 000	004$\bar{4}$	008$\bar{8}$	013	017$\bar{7}$	021$\bar{1}$	026	030$\bar{0}$	034$\bar{4}$	039	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
1000	000 000	043	087	130	173	217	260	304	347	390	
01	434	477	521	564	607	651	694	737	781	824	
02	867	911	954	997	*041	*084	*127	*171	*214	*257	
03	001 301	344	387	431	474	517	560	604	647	690	
04	733	777	820	863	906	950	993	*036	*079	*123	
05	002 166	209	252	295	339	382	425	468	511	555	
06	598	641	684	727	770	814	857	900	943	986	
07	003 029	072	115	159	202	245	288	331	374	417	43 43
08	460	503	546	590	633	676	719	762	805	848	.1 4.3 4.3
09	891	934	977	*020	*063	*106	*149	*192	*235	*278	.2 8.7 8.6
1010	004 321	364	407	450	493	536	579	622	665	708	.3 13.0 12.9 .4 17.4 17.2 .5 21.7 21.5
11	751	794	837	880	923	966	*009	*051	*094	*137	.6 26.1 25.8
12	005 180	223	266	309	352	395	438	481	523	566	.7 30.4 30.1
13	609	652	695	738	781	824	866	909	952	995	.8 34.8 34.4
14	006 038	081	123	166	209	252	295	337	380	423	.9 39.1 38.7
15	466	509	551	594	637	680	722	765	808	851	
16	893	936	979	*022	*064	*107	*150	*193	*235	*278	
17	007 321	363	406	449	491	534	577	620	662	705	
18	748	790	833	875	918	961	*003	*046	*089	131	
19	008 174	217	259	302	344	387	430	472	515	557	
1020	600	642	685	728	770	813	855	898	940	983	
21	009 025	068	111	153	196	238	281	323	366	408	42 42
22	451	493	536	578	621	663	706	748	790	833	.1 4.2 4.2
23	875	918	960	*003	*045	*088	*130	*172	*215	*257	.2 8.5 8.4
24	010 300	342	385	427	469	512	554	596	639	681	.3 12.7 12.6
25	724	766	808	851	893	935	978	*020	*062	*105	.4 17.0 16.8
26	011 147	189	232	274	316	359	401	443	486	528	.5 21.2 21.0
27	570	612	655	697	739	782	824	866	908	951	.6 25.5 25.2
28	993	*035	*077	*120	*162	*204	*246	*288	*331	*373	.7 29.7 29.4
29	012 415	457	500	542	584	626	668	710	753	795	.8 34.0 33.6 .9 38.2 37.8
1030	837	879	921	963	*006	*048	*090	*132	174	216	
31	013 258	301	343	385	427	469	511	553	595	637	
32	679	722	764	806	848	890	932	974	*016	*058	
33	014 100	142	184	226	268	310	352	394	436	478	
34	520	562	604	646	688	730	772	814	856	898	
35	940	982	*024	*066	*108	*150	*192	*234	*276	*318	
36	015 360	401	443	485	527	569	611	653	695	737	
37	779	820	862	904	946	988	*030	*072	*113	155	41 41
38	016 197	239	281	323	364	406	448	490	532	573	.1 4.1 4.1
39	615	657	699	741	782	824	866	908	950	991	.2 8.3 8.2
1040	017 033	075	117	158	200	242	284	325	367	409	.3 12.4 12.3 .4 16.6 16.4 .5 20.7 20.5
41	450	492	534	576	617	659	701	742	784	826	.6 24.9 24.6
42	867	909	951	992	*034	*076	*117	*159	*201	*242	.7 29.0 28.7
43	018 284	326	367	409	451	492	534	575	617	659	.8 33.2 32.8
44	700	742	783	825	867	908	950	991	*033	*074	.9 37.3 36.9
45	019 116	158	199	241	282	324	365	407	448	490	
46	531	573	614	656	697	739	780	822	863	905	
47	946	988	*029	*071	*112	*154	*195	*237	*278	*320	
48	020 361	402	444	485	527	568	610	651	692	734	
49	775	817	858	899	941	982	*024	*065	*106	*148	
1050	021 189	230	272	313	354	396	437	478	520	561	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

N.	0	1	2	3	4	5	6	7	8	9	P. P.
1050	021 189	230	272	313	354	396	437	478	520	561	
											41
51	602	644	685	726	768	809	850	892	933	974	.1 | 4.1
52	022 015	057	098	139	181	222	263	304	346	387	.2 | 8.2
53	428	469	511	552	593	634	676	717	758	799	.3 | 12.3
54	840	882	923	964	*005	*046	*088	*129	*170	*211	.4 | 16.4
55	023 252	293	335	376	417	458	499	540	581	623	.5 | 20.5
56	664	705	746	787	828	869	910	951	993	*034	.6 | 24.6
57	024 075	116	157	198	239	280	321	362	403	444	.7 | 28.7
58	485	526	568	609	650	691	732	773	814	855	.8 | 32.8
59	896	937	978	*019	*060	*101	*142	*183	*224	*265	.9 | 36.9
1060	025 306	347	388	429	469	510	551	592	633	674	
											41
61	715	756	797	838	879	920	961	*002	*042	*083	.1 | 4.1
62	026 124	165	206	247	288	329	370	410	451	492	.2 | 8.2
63	533	574	615	656	696	737	778	819	860	901	.3 | 12.3
64	941	982	*023	*064	*105	*145	*186	*227	*268	*309	.4 | 16.4
65	027 349	390	431	472	512	553	594	635	675	716	.5 | 20.5
66	757	798	838	879	920	961	*001	*042	*083	*123	.6 | 24.6
67	028 164	205	246	286	327	368	408	449	490	530	.7 | 28.7
68	571	612	652	693	734	774	815	856	896	937	.8 | 32.8
69	977	*018	*059	*099	*140	*181	*221	*262	*302	*343	.9 | 36.9
1070	029 384	424	465	505	546	586	627	668	708	749	
											40
71	789	830	870	911	951	992	*032	*073	*114	*154	.1 | 4.0
72	030 195	235	276	316	357	397	438	478	519	559	.2 | 8.1
73	599	640	680	721	761	802	842	883	923	964	.3 | 12.1
74	031 004	044	085	125	166	206	247	287	327	368	.4 | 16.2
75	408	449	489	529	570	610	651	691	731	772	.5 | 20.2
76	812	852	893	933	973	*014	*054	*094	*135	*175	.6 | 24.3
77	032 215	256	296	336	377	417	457	498	538	578	.7 | 28.3
78	619	659	699	739	780	820	860	900	941	981	.8 | 32.4
79	033 021	061	102	142	182	222	263	303	343	383	.9 | 36.4
1080	424	464	504	544	584	625	665	705	745	785	
											40
81	825	866	906	946	986	*026	*066	*107	147	187	.1 | 4.0
82	034 227	267	307	347	388	428	468	508	548	588	.2 | 8.0
83	628	668	708	748	789	829	869	909	949	989	.3 | 12.0
84	035 029	069	109	149	189	229	269	309	349	389	.4 | 16.0
85	429	470	510	550	590	630	670	710	750	790	.5 | 20.0
86	830	870	910	950	990	*029	*069	*109	*149	*189	.6 | 24.0
87	036 229	269	309	349	389	429	469	509	549	589	.7 | 28.0
88	629	669	709	748	788	828	868	908	948	988	.8 | 32.0
89	037 028	068	107	147	187	227	267	307	347	386	.9 | 36.0
1090	426	466	506	546	586	625	665	705	745	785	
											39
91	825	864	904	944	984	*023	*063	*103	143	183	.1 | 3.9
92	038 222	262	302	342	381	421	461	501	540	580	.2 | 7.9
93	620	660	699	739	779	819	858	898	938	977	.3 | 11.8
94	039 017	057	096	136	176	216	255	295	335	374	.4 | 15.8
95	414	454	493	533	572	612	652	691	731	771	.5 | 19.7
96	810	850	890	929	969	*008	*048	*088	*127	*167	.6 | 23.7
97	040 206	246	286	325	365	404	444	483	523	563	.7 | 27.6
98	602	642	681	721	760	800	839	879	918	958	.8 | 31.6
99	997	*037	*076	*116	*155	*195	*234	*274	*313	*353	.9 | 35.5
1100	041 392	432	471	511	550	590	629	669	708	748	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

′	Log. Sin.	D	Log. Tan.	Com. D.	Log. Cot.	Log. Cos.	
0	$-\infty$		$-\infty$		$+\infty$	0.00 000	60
1	6.46 372		6.46 372		3.53 627	0.00 000	59
2	6.76 475	30103	6.76 475	30103	3.23 524	0.00 000	58
3	6.94 084	17609	6.94 084	17609	3.05 915	0.00 000	57
4	7.06 578	12494	7.06 578	12494	2.93 421	0.00 000	56
5	7.16 269	9691	7.16 265	9691	2.83 730	0.00 000	55
6	7.24 187	7918	7.24 188	7918	2.75 812	0.00 000	54
7	7.30 882	6695	7.30 882	6694	2.69 117	0.00 000	53
8	7.36 681	5799	7.36 681	5799	2.63 318	0.00 000	52
9	7.41 797	5115	7.41 797	5115	2.58 203	0.00 000	51
10	7.46 372	4575	7.46 372	4575	2.53 627	0.00 000	50
11	7.50 512	4139	7.50 512	4139	2.49 488	0.00 000	49
12	7.54 290	3778	7.54 291	3779	2.45 709	9.99 999	48
13	7.57 767	3476	7.57 767	3476	2.42 233	9.99 999	47
14	7.60 985	3218	7.60 985	3218	2.39 014	9.99 999	46
15	7.63 981	2996	7.63 982	2996	2.36 018	9.99 999	45
16	7.66 784	2803	7.66 785	2803	2.33 215	9.99 999	44
17	7.69 417	2633	7.69 418	2633	2.30 582	9.99 999	43
18	7.71 899	2482	7.71 900	2482	2.28 099	9.99 999	42
19	7.74 248	2348	7.74 248	2348	2.25 751	9.99 999	41
20	7.76 475	2227	7.76 476	2227	2.23 524	9.99 999	40
21	7.78 594	2119	7.78 595	2119	2.21 405	9.99 999	39
22	7.80 614	2020	7.80 615	2020	2.19 384	9.99 999	38
23	7.82 545	1930	7.82 546	1930	2.17 454	9.99 999	37
24	7.84 393	1848	7.84 394	1848	2.15 605	9.99 999	36
25	7.86 166	1772	7.86 167	1773	2.13 832	9.99 999	35
26	7.87 869	1703	7.87 871	1703	2.12 129	9.99 999	34
27	7.89 508	1639	7.89 510	1639	2.10 490	9.99 998	33
28	7.91 088	1579	7.91 089	1579	2.08 910	9.99 998	32
29	7.92 612	1524	7.92 613	1524	2.07 386	9.99 998	31
30	7.94 084	1472	7.94 086	1472	2.05 914	9.99 998	30
31	7.95 508	1424	7.95 510	1424	2.04 490	9.99 998	29
32	7.96 887	1379	7.96 889	1379	2.03 111	9.99 998	28
33	7.98 223	1336	7.98 225	1336	2.01 774	9.99 998	27
34	7.99 520	1296	7.99 522	1296	2.00 478	9.99 998	26
35	8.00 778	1258	8.00 781	1259	1.99 219	9.99 997	25
36	8.02 002	1223	8.02 004	1223	1.97 995	9.99 997	24
37	8.03 192	1190	8.03 194	1190	1.96 805	9.99 997	23
38	8.04 350	1158	8.04 352	1158	1.95 647	9.99 997	22
39	8.05 478	1128	8.05 481	1128	1.94 519	9.99 997	21
40	8.06 577	1099	8.06 580	1099	1.93 419	9.99 997	20
41	8.07 650	1072	8.07 653	1072	1.92 347	9.99 997	19
42	8.08 696	1046	8.08 699	1046	1.91 300	9.99 997	18
43	8.09 718	1022	8.09 721	1022	1.90 278	9.99 996	17
44	8.10 716	998	8.10 720	999	1.89 279	9.99 996	16
45	8.11 692	976	8.11 696	976	1.88 303	9.99 996	15
46	8.12 647	954	8.12 651	954	1.87 349	9.99 996	14
47	8.13 581	934	8.13 585	934	1.86 415	9.99 996	13
48	8.14 495	914	8.14 499	914	1.85 500	9.99 996	12
49	8.15 390	895	8.15 395	895	1.84 605	9.99 995	11
50	8.16 268	877	8.16 272	877	1.83 727	9.99 995	10
51	8.17 128	860	8.17 133	860	1.82 867	9.99 995	9
52	8.17 971	843	8.17 976	843	1.82 023	9.99 995	8
53	8.18 798	827	8.18 803	827	1.81 196	9.99 995	7
54	8.19 610	811	8.19 615	812	1.80 384	9.99 994	6
55	8.20 407	797	8.20 412	797	1.79 587	9.99 994	5
56	8.21 189	782	8.21 195	783	1.78 804	9.99 994	4
57	8.21 958	768	8.21 964	768	1.78 036	9.99 994	3
58	8.22 713	755	8.22 719	755	1.77 280	9.99 994	2
59	8.23 455	742	8.23 462	742	1.76 538	9.99 993	1
60	8.24 185	730	8.24 192	730	1.75 808	9.99 993	0
	Log. Cos.	D	Log. Cot.	Com. D.	Log. Tan.	Log. Sin.	′

′	Log. Sin.	D	Log. Tan.	Com. D.	Log. Cot.	Log. Cos.	
0	8.24 185	718	8.24 192	718	1.75 808	9.99 993	6
1	8.24 903	706	8.24 910	706	1.75 090	9.99 993	5
2	8.25 609	694	8.25 616	695	1.74 383	9.99 993	5
3	8.26 304	684	8.26 311	684	1.73 688	9.99 992	5
4	8.26 988	673	8.26 995	673	1.73 004	9.99 992	5
5	8.27 661	663	8.27 669	663	1.72 331	9.99 992	5
6	8.28 324	653	8.28 332	653	1.71 667	9.99 992	5
7	8.28 977	643	8.28 985	643	1.71 014	9.99 992	5
8	8.29 620	634	8.29 629	634	1.70 371	9.99 991	5
9	8.30 254	625	8.30 263	625	1.69 736	9.99 991	5
10	8.30 879	616	8.30 888	616	1.69 111	9.99 991	5
11	8.31 495	607	8.31 504	607	1.68 495	9.99 990	5
12	8.32 102	599	8.32 112	599	1.67 888	9.99 990	5
13	8.32 701	591	8.32 711	591	1.67 288	9.99 990	5
14	8.33 292	583	8.33 302	583	1.66 697	9.99 990	5
15	8.33 875	575	8.33 885	575	1.66 114	9.99 989	5
16	8.34 450	567	8.34 461	568	1.65 539	9.99 989	5
17	8.35 018	560	8.35 029	560	1.64 971	9.99 989	5
18	8.35 578	553	8.35 589	553	1.64 410	9.99 989	5
19	8.36 131	546	8.36 143	546	1.63 857	9.99 988	5
20	8.36 677	539	8.36 689	539	1.63 310	9.99 988	4
21	8.37 217	533	8.37 229	533	1.62 771	9.99 988	4
22	8.37 750	526	8.37 762	527	1.62 238	9.99 987	4
23	8.38 276	520	8.38 289	520	1.61 711	9.99 987	4
24	8.38 796	514	8.38 809	514	1.61 191	9.99 987	4
25	8.39 310	508	8.39 323	508	1.60 676	9.99 986	4
26	8.39 818	502	8.39 831	502	1.60 168	9.99 986	4
27	8.40 320	496	8.40 334	496	1.59 666	9.99 986	4
28	8.40 816	491	8.40 830	491	1.59 169	9.99 986	4
29	8.41 307	485	8.41 321	485	1.58 678	9.99 985	4
30	8.41 792	480	8.41 807	480	1.58 193	9.99 985	4
31	8.42 271	475	8.42 287	475	1.57 713	9.99 985	4
32	8.42 746	469	8.42 762	469	1.57 238	9.99 984	4
33	8.43 215	464	8.43 231	464	1.56 768	9.99 984	4
34	8.43 680	459	8.43 696	460	1.56 304	9.99 984	4
35	8.44 139	454	8.44 156	455	1.55 844	9.99 983	4
36	8.44 594	450	8.44 611	450	1.55 389	9.99 983	4
37	8.45 044	445	8.45 061	445	1.54 938	9.99 982	4
38	8.45 489	440	8.45 507	441	1.54 493	9.99 982	4
39	8.45 930	436	8.45 948	437	1.54 052	9.99 982	4
40	8.46 366	432	8.46 385	432	1.53 615	9.99 981	4
41	8.46 798	428	8.46 817	428	1.53 183	9.99 981	4
42	8.47 226	423	8.47 245	424	1.52 754	9.99 981	4
43	8.47 650	419	8.47 669	419	1.52 330	9.99 980	4
44	8.48 069	415	8.48 089	416	1.51 911	9.99 980	4
45	8.48 485	411	8.48 505	412	1.51 495	9.99 979	4
46	8.48 896	407	8.48 917	408	1.51 083	9.99 979	4
47	8.49 304	404	8.49 325	404	1.50 675	9.99 979	4
48	8.49 708	400	8.49 729	400	1.50 270	9.99 978	4
49	8.50 108	396	8.50 130	396	1.49 870	9.99 978	4
50	8.50 504	393	8.50 526	393	1.49 473	9.99 978	4
51	8.50 897	389	8.50 920	390	1.49 080	9.99 977	4
52	8.51 286	386	8.51 310	386	1.48 690	9.99 977	4
53	8.51 672	382	8.51 696	383	1.48 304	9.99 976	4
54	8.52 055	379	8.52 079	379	1.47 921	9.99 976	4
55	8.52 434	375	8.52 458	375	1.47 541	9.99 975	4
56	8.52 810	373	8.52 835	373	1.47 165	9.99 975	4
57	8.53 183	369	8.53 208	370	1.46 792	9.99 975	4
58	8.53 552	366	8.53 578	366	1.46 422	9.99 974	4
59	8.53 918	363	8.53 944	364	1.46 055	9.99 974	4
60	8.54 282		8.54 308		1.45 691	9.99 973	4
	Log. Cos.	D	Log. Cot.	Com. D.	Log. Tan.	Log. Sin.	

′	Log. Sin.	D	Log. Tan.	Com. D.	Log. Cot.	Log. Cos.	
0	8.54 282	360	8.54 308	360	1.45 691	9.99 973	60
1	8.54 642	357	8.54 669	358	1.45 331	9.99 973	59
2	8.54 999	354	8.55 027	354	1.44 973	9.99 972	58
3	8.55 354	351	8.55 381	352	1.44 618	9.99 972	57
4	8.55 705	348	8.55 733	349	1.44 266	9.99 971	56
5	8.56 054	346	8.56 083	346	1.43 917	9.99 971	55
6	8.56 400	343	8.56 429	343	1.43 571	9.99 971	54
7	8.56 743	340	8.56 772	341	1.43 227	9.99 970	53
8	8.57 083	338	8.57 113	338	1.42 886	9.99 970	52
9	8.57 421	335	8.57 452	335	1.42 548	9.99 969	51
10	8.57 756	332	8.57 787	333	1.42 212	9.99 969	50
11	8.58 089	330	8.58 121	330	1.41 879	9.99 968	49
12	8.58 419	327	8.58 451	328	1.41 548	9.99 968	48
13	8.58 747	325	8.58 779	325	1.41 220	9.99 967	47
14	8.59 072	323	8.59 105	323	1.40 895	9.99 967	46
15	8.59 395	320	8.59 428	320	1.40 571	9.99 966	45
16	8.59 715	318	8.59 749	318	1.40 251	9.99 966	44
17	8.60 033	316	8.60 067	316	1.39 932	9.99 965	43
18	8.60 349	313	8.60 384	314	1.39 616	9.99 965	42
19	8.60 662	311	8.60 698	311	1.39 302	9.99 964	41
20	8.60 973	309	8.61 009	309	1.38 990	9.99 964	40
21	8.61 282	306	8.61 319	307	1.38 681	9.99 963	39
22	8.61 589	304	8.61 626	305	1.38 374	9.99 963	38
23	8.61 893	302	8.61 931	303	1.38 068	9.99 962	37
24	8.62 196	300	8.62 234	300	1.37 765	9.99 962	36
25	8.62 496	298	8.62 535	299	1.37 465	9.99 961	35
26	8.62 795	296	8.62 834	297	1.37 166	9.99 961	34
27	8.63 091	294	8.63 131	294	1.36 869	9.99 960	33
28	8.63 385	292	8.63 425	293	1.36 574	9.99 959	32
29	8.63 677	290	8.63 718	291	1.36 281	9.99 959	31
30	8.63 968	288	8.64 009	288	1.35 990	9.99 958	30
31	8.64 256	286	8.64 298	287	1.35 702	9.99 958	29
32	8.64 543	284	8.64 585	285	1.35 414	9.99 957	28
33	8.64 827	282	8.64 870	283	1.35 129	9.99 957	27
34	8.65 110	281	8.65 153	281	1.34 846	9.99 956	26
35	8.65 391	279	8.65 435	280	1.34 565	9.99 956	25
36	8.65 670	277	8.65 715	278	1.34 285	9.99 955	24
37	8.65 947	275	8.65 993	276	1.34 007	9.99 954	23
38	8.66 223	274	8.66 269	274	1.33 731	9.99 954	22
39	8.66 497	272	8.66 543	272	1.33 456	9.99 953	21
40	8.66 769	270	8.66 816	271	1.33 184	9.99 953	20
41	8.67 039	268	8.67 087	269	1.32 913	9.99 952	19
42	8.67 308	267	8.67 356	267	1.32 643	9.99 952	18
43	8.67 575	265	8.67 624	266	1.32 376	9.99 951	17
44	8.67 840	264	8.67 890	264	1.32 110	9.99 950	16
45	8.68 104	262	8.68 154	262	1.31 845	9.99 950	15
46	8.68 366	260	8.68 417	261	1.31 583	9.99 949	14
47	8.68 627	259	8.68 678	259	1.31 321	9.99 948	13
48	8.68 886	257	8.68 938	258	1.31 062	9.99 948	12
49	8.69 144	256	8.69 196	256	1.30 803	9.99 947	11
50	8.69 400	254	8.69 453	255	1.30 547	9.99 947	10
51	8.69 654	253	8.69 708	253	1.30 292	9.99 946	9
52	8.69 907	251	8.69 961	252	1.30 038	9.99 945	8
53	8.70 159	250	8.70 214	250	1.29 786	9.99 945	7
54	8.70 409	248	8.70 464	249	1.29 535	9.99 944	6
55	8.70 657	247	8.70 714	248	1.29 286	9.99 943	5
56	8.70 905	245	8.70 962	246	1.29 038	9.99 943	4
57	8.71 150	244	8.71 208	245	1.28 791	9.99 942	3
58	8.71 395	243	8.71 453	243	1.28 546	9.99 942	2
59	8.71 638	241	8.71 697	242	1.28 303	9.99 941	1
60	8.71 880		8.71 939		1.28 060	9.99 940	0
	Log. Cos.	D	Log. Cot.	Com. D.	Log. Tan.	Log. Sin.	′

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.	
0	8.71 880	240	8.71 939	241	1.28 060	9.99 940	60
1	8.72 120	239	8.72 180	240	1.27 819	9.99 940	59
2	8.72 355	237	8.72 420	238	1.27 579	9.99 939	58
3	8.72 597	236	8.72 659	237	1.27 341	9.99 938	57
4	8.72 833	235	8.72 896	235	1.27 104	9.99 938	56
5	8.73 069	233	8.73 131	235	1.26 868	9.99 937	55
6	8.73 302	233	8.73 366	233	1.26 633	9.99 936	54
7	8.73 535	231	8.73 599	232	1.26 400	9.99 935	53
8	8.73 766	230	8.73 831	231	1.26 168	9.99 935	52
9	8.73 997	229	8.74 062	229	1.25 937	9.99 934	51
10	8.74 226	227	8.74 292	228	1.25 708	9.99 933	50
11	8.74 453	226	8.74 520	227	1.25 479	9.99 933	49
12	8.74 680	225	8.74 748	226	1.25 252	9.99 932	48
13	8.74 905	224	8.74 974	225	1.25 026	9.99 931	47
14	8.75 129	223	8.75 199	223	1.24 801	9.99 931	46
15	8.75 353	221	8.75 422	223	1.24 577	9.99 930	45
16	8.75 574	221	8.75 645	221	1.24 354	9.99 929	44
17	8.75 795	219	8.75 867	220	1.24 133	9.99 928	43
18	8.76 015	218	8.76 087	219	1.23 913	9.99 928	42
19	8.76 233	217	8.76 306	218	1.23 693	9.99 927	41
20	8.76 451	216	8.76 524	217	1.23 475	9.99 926	40
21	8.76 667	215	8.76 741	216	1.23 258	9.99 925	39
22	8.76 883	214	8.76 958	214	1.23 042	9.99 925	38
23	8.77 097	213	8.77 172	214	1.22 827	9.99 924	37
24	8.77 310	212	8.77 386	213	1.22 613	9.99 923	36
25	8.77 522	211	8.77 599	212	1.22 400	9.99 922	35
26	8.77 733	210	8.77 811	210	1.22 188	9.99 922	34
27	8.77 943	209	8.78 022	210	1.21 978	9.99 921	33
28	8.78 152	208	8.78 232	209	1.21 768	9.99 920	32
29	8.78 360	207	8.78 441	207	1.21 559	9.99 919	31
30	8.78 567	206	8.78 648	207	1.21 351	9.99 919	30
31	8.78 773	205	8.78 855	206	1.21 144	9.99 918	29
32	8.78 978	204	8.79 061	206	1.20 938	9.99 917	28
33	8.79 183	203	8.79 266	204	1.20 734	9.99 916	27
34	8.79 386	202	8.79 470	204	1.20 530	9.99 916	26
35	8.79 588	201	8.79 673	203	1.20 327	9.99 915	25
36	8.79 789	200	8.79 875	202	1.20 125	9.99 914	24
37	8.79 989	199	8.80 076	201	1.19 923	9.99 913	23
38	8.80 189	198	8.80 276	200	1.19 723	9.99 912	22
39	8.80 387	197	8.80 476	199	1.19 524	9.99 912	21
40	8.80 585	197	8.80 674	198	1.19 326	9.99 911	20
41	8.80 782	195	8.80 871	197	1.19 128	9.99 910	19
42	8.80 977	195	8.81 068	197	1.18 931	9.99 909	18
43	8.81 172	194	8.81 264	195	1.18 736	9.99 908	17
44	8.81 366	193	8.81 459	195	1.18 541	9.99 907	16
45	8.81 560	192	8.81 653	194	1.18 347	9.99 907	15
46	8.81 752	191	8.81 846	193	1.18 154	9.99 906	14
47	8.81 943	191	8.82 038	192	1.17 961	9.99 905	13
48	8.82 134	189	8.82 230	191	1.17 770	9.99 904	12
49	8.82 324	189	8.82 420	190	1.17 579	9.99 903	11
50	8.82 513	188	8.82 610	190	1.17 389	9.99 902	10
51	8.82 701	187	8.82 799	189	1.17 201	9.99 902	9
52	8.82 888	186	8.82 987	188	1.17 012	9.99 901	8
53	8.83 075	185	8.83 175	187	1.16 825	9.99 900	7
54	8.83 260	185	8.83 361	186	1.16 638	9.99 899	6
55	8.83 445	184	8.83 547	185	1.16 453	9.99 898	5
56	8.83 629	183	8.83 732	185	1.16 268	9.99 897	4
57	8.83 813	182	8.83 916	184	1.16 083	9.99 896	3
58	8.83 995	182	8.84 100	183	1.15 900	9.99 896	2
59	8.84 177	181	8.84 282	182	1.15 717	9.99 895	1
60	8.84 358		8.84 464	182	1.15 535	9.99 894	0
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	′

P. P.				
	330	320	310	30
6	33.0	32.0	31.0	30
7	38.5	37.3	36.1	35
8	44.0	42.6	41.3	40
9	49.5	48.0	46.5	45
10	55.0	53.3	51.6	50
20	110.0	106.6	103.3	100
30	165.0	160.0	155.0	150
40	220.0	213.3	206.6	200
50	275.0	266.6	258.3	250

	290	280	270	26
6	29.0	28.0	27.0	26
7	33.8	32.6	31.5	30
8	38.6	37.3	36.0	34
9	43.5	42.0	40.5	39
10	48.3	46.6	45.0	43
20	96.6	93.3	90.0	86
30	145.0	140.0	135.0	130
40	193.3	186.6	180.0	173
50	241.6	233.3	225.0	216

	250	240	230	22
6	25.0	24.0	23.0	22
7	29.1	28.0	26.8	25
8	33.3	32.0	30.6	29
9	37.5	36.0	34.5	33
10	41.6	40.0	38.3	36
20	83.3	80.0	76.6	73
30	125.0	120.0	115.0	110
40	166.6	160.0	153.3	146
50	208.3	200.0	191.6	183

	210	200	190	18
6	21.0	20.0	19.0	18
7	24.5	23.3	22.1	21
8	28.0	26.6	25.3	24
9	31.5	30.0	28.5	27
10	35.0	33.3	31.6	30
20	70.0	66.6	63.3	60
30	105.0	100.0	95.0	90
40	140.0	133.3	126.6	120
50	175.0	166.6	158.3	150

	9	9	8	7	6	5
6	0.9	0.9	0.8	0.7	0.6	0.
7	1.1	1.0	0.9	0.8	0.7	0.
8	1.2	1.2	1.0	0.9	0.8	0.
9	1.4	1.3	1.2	1.0	0.9	0.
10	1.6	1.5	1.3	1.1	1.0	0.
20	3.1	3.0	2.6	2.3	2.0	1.
30	4.7	4.5	4.0	3.5	3.0	2.
40	6.3	6.0	5.3	4.6	4.0	3.
50	7.9	7.5	6.6	5.8	5.0	4.

	4	4	3	2	1	0
6	0.4	0.4	0.3	0.2	0.1	0.
7	0.5	0.4	0.3	0.2	0.1	0.
8	0.6	0.5	0.4	0.2	0.1	0.
9	0.7	0.6	0.4	0.3	0.1	0.
10	0.7	0.6	0.5	0.3	0.1	0.
20	1.5	1.3	1.0	0.6	0.3	0.
30	2.2	2.0	1.5	1.0	0.5	0.
40	3.0	2.6	2.0	1.3	0.6	0.
50	3.7	3.3	2.5	1.6	0.8	0.

P. P.

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.	
0	8.84 358	180	8.84 464	181	1.15 535	9.99 894	60
1	8.84 538	180	8.84 645	180	1.15 354	9.99 893	59
2	8.84 718	178	8.84 826	179	1.15 174	9.99 892	58
3	8.84 897	178	8.85 005	179	1.14 994	9.99 891	57
4	8.85 075	177	8.85 184	178	1.14 815	9.99 890	56
5	8.85 252	176	8.85 363	177	1.14 637	9.99 889	55
6	8.85 429	176	8.85 540	177	1.14 459	9.99 888	54
7	8.85 605	175	8.85 717	176	1.14 283	9.99 888	53
8	8.85 780	174	8.85 893	176	1.14 107	9.99 887	52
9	8.85 954	174	8.86 068	175	1.13 931	9.99 886	51
10	8.86 128	173	8.86 243	175	1.13 756	9.99 885	50
11	8.86 301	173	8.86 417	174	1.13 582	9.99 884	49
12	8.86 474	171	8.86 590	173	1.13 409	9.99 883	48
13	8.86 645	171	8.86 763	172	1.13 237	9.99 882	47
14	8.86 816	170	8.86 935	172	1.13 065	9.99 881	46
15	8.86 987	169	8.87 106	171	1.12 893	9.99 880	45
16	8.87 156	169	8.87 277	170	1.12 723	9.99 879	44
17	8.87 325	168	8.87 447	170	1.12 553	9.99 878	43
18	8.87 494	167	8.87 616	169	1.12 384	9.99 877	42
19	8.87 661	167	8.87 785	169	1.12 215	9.99 876	41
20	8.87 828	167	8.87 953	168	1.12 047	9.99 875	40
21	8.87 995	166	8.88 120	167	1.11 880	9.99 874	39
22	8.88 160	165	8.88 287	167	1.11 713	9.99 874	38
23	8.88 326	166	8.88 453	166	1.11 547	9.99 873	37
24	8.88 490	164	8.88 618	165	1.11 381	9.99 872	36
25	8.88 654	163	8.88 783	165	1.11 216	9.99 871	35
26	8.88 817	163	8.88 947	164	1.11 052	9.99 870	34
27	8.88 980	162	8.89 111	163	1.10 889	9.99 869	33
28	8.89 142	162	8.89 274	163	1.10 726	9.99 868	32
29	8.89 303	161	8.89 436	162	1.10 563	9.99 867	31
30	8.89 464	161	8.89 598	162	1.10 401	9.99 866	30
31	8.89 624	160	8.89 759	161	1.10 240	9.99 865	29
32	8.89 784	159	8.89 920	161	1.10 079	9.99 864	28
33	8.89 943	159	8.90 080	160	1.09 919	9.99 863	27
34	8.90 101	158	8.90 240	159	1.09 760	9.99 862	26
35	8.90 259	158	8.90 398	158	1.09 601	9.99 861	25
36	8.90 417	157	8.90 557	158	1.09 443	9.99 860	24
37	8.90 573	156	8.90 714	157	1.09 285	9.99 859	23
38	8.90 729	156	8.90 872	157	1.09 128	9.99 858	22
39	8.90 885	156	8.91 028	156	1.08 971	9.99 857	21
40	8.91 040	155	8.91 184	156	1.08 815	9.99 856	20
41	8.91 195	154	8.91 340	155	1.08 660	9.99 855	19
42	8.91 349	154	8.91 495	155	1.08 505	9.99 853	18
43	8.91 502	153	8.91 649	154	1.08 350	9.99 852	17
44	8.91 655	153	8.91 803	154	1.08 196	9.99 851	16
45	8.91 807	152	8.91 957	153	1.08 043	9.99 850	15
46	8.91 959	152	8.92 109	152	1.07 890	9.99 849	14
47	8.92 110	151	8.92 262	152	1.07 738	9.99 848	13
48	8.92 261	150	8.92 413	151	1.07 586	9.99 847	12
49	8.92 411	150	8.92 565	150	1.07 435	9.99 846	11
50	8.92 561	149	8.92 715	150	1.07 284	9.99 845	10
51	8.92 710	149	8.92 866	149	1.07 134	9.99 844	9
52	8.92 858	148	8.93 015	149	1.06 984	9.99 843	8
53	8.93 007	147	8.93 164	149	1.06 835	9.99 842	7
54	8.93 154	147	8.93 313	148	1.06 686	9.99 841	6
55	8.93 301	146	8.93 461	148	1.06 538	9.99 840	5
56	8.93 448	146	8.93 609	147	1.06 390	9.99 839	4
57	8.93 594	146	8.93 756	146	1.06 243	9.99 837	3
58	8.93 740	145	8.93 903	146	1.06 097	9.99 836	2
59	8.93 885	144	8.94 049	145	1.05 950	9.99 835	1
60	8.94 028		8.94 195		1.05 805	9.99 834	0
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	′

P. P.				
	181	180	178	176
6	18.1	18.0	17.8	17.6
7	21.1	21.0	20.7	20.5
8	24.1	24.0	23.7	23.4
9	27.1	27.0	26.7	26.4
10	30.1	30.0	29.6	29.3
20	60.3	60.0	59.3	58.6
30	90.5	90.0	89.0	88.0
40	120.6	120.0	118.6	117.3
50	150.8	150.0	148.3	146.6
	174	172	170	168
6	17.4	17.2	17.0	16.8
7	20.3	20.0	19.8	19.6
8	23.2	22.9	22.6	22.4
9	26.1	25.8	25.5	25.2
10	29.0	28.6	28.3	28.0
20	58.0	57.3	56.6	56.0
30	87.0	86.0	85.0	84.0
40	116.0	114.6	113.3	112.0
50	145.0	143.3	141.6	140.0
	166	164	162	160
6	16.6	16.4	16.2	16.0
7	19.3	19.1	18.9	18.6
8	22.1	21.8	21.6	21.3
9	24.9	24.6	24.3	24.0
10	27.6	27.3	27.0	26.6
20	55.3	54.6	54.0	53.3
30	83.0	82.0	81.0	80.0
40	110.6	109.3	108.0	106.6
50	138.3	136.6	135.0	133.3
	158	156	154	152
6	15.8	15.6	15.4	15.2
7	18.4	18.2	17.9	17.7
8	21.0	20.8	20.5	20.2
9	23.7	23.4	23.1	22.8
10	26.3	26.0	25.6	25.3
20	52.6	52.0	51.3	50.6
30	79.0	78.0	77.0	76.0
40	105.3	104.0	102.6	101.3
50	131.6	130.0	128.3	126.6
	150	149	148	147
6	15.0	14.9	14.8	14.7
7	17.5	17.4	17.2	17.1
8	20.0	19.8	19.7	19.6
9	22.5	22.3	22.2	22.0
10	25.0	24.8	24.6	24.5
20	50.0	49.6	49.3	49.0
30	75.0	74.5	74.0	73.5
40	100.0	99.3	98.6	98.0
50	125.0	124.1	123.3	122.5
	146	145	1	1	0
6	14.6	14.5	0.1	0.1	0.0
7	17.0	16.9	0.2	0.1	0.0
8	19.4	19.3	0.2	0.1	0.0
9	21.9	21.7	0.2	0.1	0.1
10	24.3	24.1	0.2	0.1	0.1
20	48.6	48.3	0.5	0.3	0.1
30	73.0	72.5	0.7	0.5	0.2
40	97.3	96.6	1.0	0.6	0.3
50	121.6	120.8	1.2	0.8	0.4

P. P.

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.	
0	8.94 029	144	8.94 195	145	1.05 805	9.99 834	60
1	8.94 174	143	8.94 340	144	1.05 659	9.99 833	59
2	8.94 317	143	8.94 485	144	1.05 515	9.99 832	58
3	8.94 460	143	8.94 629	144	1.05 370	9.99 831	57
4	8.94 603	142	8.94 773	143	1.05 226	9.99 830	56
5	8.94 745	142	8.94 917	142	1.05 083	9.99 829	55
6	8.94 887	141	8.95 059	142	1.04 940	9.99 827	54
7	8.95 028	141	8.95 202	142	1.04 798	9.99 826	53
8	8.95 169	140	8.95 344	141	1.04 656	9.99 825	52
9	8.95 310	140	8.95 485	141	1.04 514	9.99 824	51
10	8.95 450	139	8.95 626	141	1.04 373	9.99 823	50
11	8.95 589	139	8.95 767	140	1.04 232	9.99 822	49
12	8.95 728	138	8.95 907	140	1.04 092	9.99 821	48
13	8.95 867	138	8.96 047	139	1.03 952	9.99 819	47
14	8.96 005	138	8.96 186	139	1.03 813	9.99 818	46
15	8.96 143	137	8.96 325	138	1.03 674	9.99 817	45
16	8.96 280	137	8.96 464	138	1.03 536	9.99 816	44
17	8.96 417	136	8.96 602	138	1.03 398	9.99 815	43
18	8.96 553	136	8.96 739	137	1.03 260	9.99 814	42
19	8.96 689	135	8.96 876	137	1.03 123	9.99 813	41
20	8.96 825	135	8.97 013	137	1.02 986	9.99 811	40
21	8.96 960	134	8.97 149	136	1.02 850	9.99 810	39
22	8.97 094	134	8.97 285	136	1.02 714	9.99 809	38
23	8.97 229	134	8.97 421	135	1.02 579	9.99 808	37
24	8.97 363	133	8.97 556	135	1.02 444	9.99 807	36
25	8.97 496	133	8.97 690	134	1.02 309	9.99 805	35
26	8.97 629	132	8.97 825	134	1.02 175	9.99 804	34
27	8.97 762	132	8.97 958	133	1.02 041	9.99 803	33
28	8.97 894	132	8.98 092	133	1.01 908	9.99 802	32
29	8.98 026	131	8.98 225	133	1.01 775	9.99 801	31
30	8.98 157	131	8.98 357	132	1.01 642	9.99 799	30
31	8.98 288	130	8.98 490	132	1.01 510	9.99 798	29
32	8.98 419	130	8.98 621	131	1.01 378	9.99 797	28
33	8.98 549	130	8.98 753	131	1.01 247	9.99 796	27
34	8.98 679	129	8.98 884	131	1.01 116	9.99 794	26
35	8.98 808	129	8.99 015	130	1.00 985	9.99 793	25
36	8.98 937	129	8.99 145	130	1.00 855	9.99 792	24
37	8.99 066	128	8.99 275	129	1.00 725	9.99 791	23
38	8.99 194	128	8.99 404	129	1.00 595	9.99 789	22
39	8.99 322	127	8.99 533	129	1.00 466	9.99 788	21
40	8.99 449	127	8.99 662	128	1.00 337	9.99 787	20
41	8.99 577	127	8.99 791	128	1.00 209	9.99 786	19
42	8.99 703	126	8.99 919	128	1.00 081	9.99 784	18
43	8.99 830	126	9.00 046	127	0.99 953	9.99 783	17
44	8.99 956	126	9.00 174	127	0.99 826	9.99 782	16
45	9.00 081	125	9.00 300	126	0.99 699	9.99 781	15
46	9.00 207	125	9.00 427	126	0.99 573	9.99 779	14
47	9.00 332	125	9.00 553	126	0.99 446	9.99 778	13
48	9.00 456	124	9.00 679	125	0.99 321	9.99 777	12
49	9.00 580	124	9.00 804	125	0.99 195	9.99 776	11
50	9.00 704	124	9.00 930	124	0.99 070	9.99 774	10
51	9.00 828	123	9.01 054	124	0.98 945	9.99 773	9
52	9.00 951	123	9.01 179	124	0.98 821	9.99 772	8
53	9.01 073	122	9.01 303	124	0.98 697	9.99 770	7
54	9.01 196	122	9.01 427	123	0.98 573	9.99 769	6
55	9.01 318	122	9.01 550	123	0.98 450	9.99 768	5
56	9.01 440	121	9.01 673	123	0.98 327	9.99 766	4
57	9.01 561	121	9.01 796	122	0.98 204	9.99 765	3
58	9.01 682	120	9.01 918	122	0.98 081	9.99 764	2
59	9.01 803	120	9.02 040	122	0.97 959	9.99 763	1
60	9.01 923	120	9.02 162	121	0.97 838	9.99 761	0
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	′

P. P.				
	145	144	143	142
6	14.5	14.4	14.3	14.2
7	16.9	16.8	16.7	16.5
8	19.3	19.2	19.0	18.9
9	21.7	21.6	21.4	21.3
10	24.1	24.0	23.8	23.6
20	48.3	48.0	47.6	47.3
30	72.5	72.0	71.5	71.0
40	96.6	96.0	95.3	94.6
50	120.8	120.0	119.1	118.3
	140	139	138	137
6	14.0	13.9	13.8	13.7
7	16.3	16.2	16.1	16.0
8	18.6	18.5	18.4	18.2
9	21.0	20.8	20.7	20.5
10	23.3	23.1	23.0	22.8
20	46.6	46.3	46.0	45.6
30	70.0	69.5	69.0	68.5
40	93.3	92.6	92.0	91.3
50	116.6	115.8	115.0	114.1
	135	134	133	13
6	13.5	13.4	13.3	13
7	15.7	15.6	15.5	15
8	18.0	17.8	17.7	17
9	20.2	20.1	19.9	19
10	22.5	22.3	22.1	22
20	45.0	44.6	44.3	44
30	67.5	67.0	66.5	66
40	90.0	89.3	88.6	88
50	112.5	111.6	110.8	110
	131	130	129	12
6	13.1	13.0	12.9	12
7	15.3	15.1	15.0	14
8	17.4	17.3	17.2	17
9	19.6	19.5	19.3	19
10	21.8	21.6	21.5	21
20	43.6	43.3	43.0	42
30	65.5	65.0	64.5	64
40	87.3	86.6	86.0	85
50	109.1	108.3	107.5	106
	127	126	125	124
6	12.7	12.6	12.5	12.4
7	14.8	14.7	14.6	14.4
8	16.9	16.8	16.6	16.5
9	19.0	18.9	18.7	18.6
10	21.1	21.0	20.8	20.6
20	42.3	42.0	41.6	41.3
30	63.5	63.0	62.5	62.0
40	84.6	84.0	83.3	82.6
50	105.8	105.0	104.1	103.3
	122	121	120	$\overline{1}$
6	12.2	12.1	12.0	0.1
7	14.2	14.1	14.0	0.2
8	16.2	16.1	16.0	0.2
9	18.3	18.1	18.0	0.2
10	20.3	20.1	20.0	0.2
20	40.6	40.3	40.0	0.5
30	61.0	60.5	60.0	0.7
40	81.3	80.6	80.0	1.0
50	101.6	100.8	100.0	1.2

P. P.

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.	
0	9.01 923	120	9.02 162	121	0.97 838	9.99 761	60
1	9.02 043	119	9.02 283	121	0.97 716	9.99 760	59
2	9.02 163	119	9.02 404	120	0.97 595	9.99 759	58
3	9.02 282	119	9.02 525	120	0.97 475	9.99 757	57
4	9.02 401	119	9.02 645	120	0.97 354	9.99 756	56
5	9.02 520	118	9.02 765	119	0.97 234	9.99 754	55
6	9.02 638	118	9.02 885	119	0.97 115	9.99 753	54
7	9.02 756	118	9.03 004	119	0.96 995	9.99 752	53
8	9.02 874	117	9.03 123	119	0.96 876	9.99 750	52
9	9.02 992	117	9.03 242	118	0.96 757	9.99 749	51
10	9.03 109	117	9.03 361	118	0.96 639	9.99 748	50
11	9.03 225	116	9.03 479	118	0.96 521	9.99 746	49
12	9.03 342	116	9.03 597	117	0.96 403	9.99 745	48
13	9.03 458	116	9.03 714	117	0.96 285	9.99 744	47
14	9.03 574	116	9.03 831	117	0.96 168	9.99 742	46
15	9.03 689	115	9.03 948	116	0.96 051	9.99 741	45
16	9.03 805	114	9.04 065	116	0.95 935	9.99 739	44
17	9.03 919	114	9.04 181	116	0.95 818	9.99 738	43
18	9.04 034	114	9.04 297	115	0.95 702	9.99 737	42
19	9.04 148	114	9.04 413	115	0.95 587	9.99 735	41
20	9.04 262	113	9.04 528	115	0.95 471	9.99 734	40
21	9.04 376	113	9.04 643	114	0.95 356	9.99 732	39
22	9.04 489	113	9.04 758	114	0.95 242	9.99 731	38
23	9.04 602	113	9.04 872	114	0.95 127	9.99 730	37
24	9.04 715	113	9.04 987	114	0.95 013	9.99 728	36
25	9.04 828	112	9.05 101	113	0.94 899	9.99 727	35
26	9.04 940	112	9.05 214	113	0.94 785	9.99 725	34
27	9.05 052	112	9.05 327	113	0.94 672	9.99 724	33
28	9.05 163	111	9.05 440	113	0.94 559	9.99 723	32
29	9.05 275	111	9.05 553	112	0.94 446	9.99 721	31
30	9.05 386	111	9.05 666	112	0.94 334	9.99 720	30
31	9.05 496	110	9.05 778	112	0.94 222	9.99 718	29
32	9.05 607	110	9.05 890	111	0.94 110	9.99 717	28
33	9.05 717	110	9.06 001	111	0.93 998	9.99 715	27
34	9.05 827	110	9.06 113	111	0.93 887	9.99 714	26
35	9.05 936	109	9.06 224	111	0.93 776	9.99 712	25
36	9.06 046	109	9.06 335	111	0.93 665	9.99 711	24
37	9.06 155	109	9.06 445	110	0.93 554	9.99 710	23
38	9.06 264	109	9.06 555	110	0.93 444	9.99 708	22
39	9.06 372	108	9.06 665	110	0.93 334	9.99 707	21
40	9.06 480	108	9.06 775	109	0.93 225	9.99 705	20
41	9.06 588	108	9.06 884	109	0.93 115	9.99 704	19
42	9.06 696	107	9.06 994	109	0.93 006	9.99 702	18
43	9.06 803	107	9.07 102	109	0.92 897	9.99 701	17
44	9.06 910	107	9.07 211	108	0.92 788	9.99 699	16
45	9.07 017	107	9.07 319	108	0.92 680	9.99 698	15
46	9.07 124	106	9.07 428	108	0.92 572	9.99 696	14
47	9.07 230	106	9.07 535	107	0.92 464	9.99 695	13
48	9.07 336	106	9.07 643	107	0.92 357	9.99 693	12
49	9.07 442	106	9.07 750	107	0.92 249	9.99 692	11
50	9.07 548	105	9.07 857	107	0.92 142	9.99 690	10
51	9.07 653	105	9.07 964	106	0.92 035	9.99 689	9
52	9.07 758	105	9.08 071	106	0.91 929	9.99 687	8
53	9.07 863	104	9.08 177	106	0.91 822	9.99 686	7
54	9.07 967	104	9.08 283	106	0.91 716	9.99 684	6
55	9.08 072	104	9.08 389	105	0.91 611	9.99 683	5
56	9.08 176	104	9.08 494	105	0.91 505	9.99 681	4
57	9.08 279	103	9.08 600	105	0.91 400	9.99 679	3
58	9.08 383	103	9.08 705	105	0.91 295	9.99 678	2
59	9.08 486	103	9.08 810	104	0.91 190	9.99 676	1
60	9.08 589	103	9.08 914	104	0.91 085	9.99 675	0
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	′

P. P.

	121	121	120	119	118
6	12.1	12.1	12.0	11.9	11.8
7	14.2	14.1	14.0	13.9	13.7
8	16.2	16.1	16.0	15.8	15.7
9	18.2	18.1	18.0	17.8	17.7
10	20.2	20.1	20.0	19.8	19.6
20	40.5	40.3	40.0	39.6	39.3
30	60.7	60.5	60.0	59.5	59.0
40	81.0	80.6	80.0	79.3	78.6
50	101.2	100.8	100.0	99.1	98.3

	117	117	116	115
6	11.7	11.7	11.6	11.5
7	13.7	13.6	13.5	13.4
8	15.6	15.6	15.4	15.3
9	17.6	17.5	17.4	17.2
10	19.6	19.5	19.3	19.1
20	39.1	39.0	38.6	38.3
30	58.7	58.5	58.0	57.5
40	78.3	78.0	77.3	76.6
50	97.9	97.5	96.6	95.8

	114	114	113	112	111
6	11.4	11.4	11.3	11.2	11.1
7	13.3	13.3	13.2	13.0	12.9
8	15.2	15.2	15.0	14.9	14.8
9	17.2	17.1	16.9	16.8	16.6
10	19.1	19.0	18.8	18.6	18.5
20	38.1	38.0	37.6	37.3	37.0
30	57.2	57.0	56.5	56.0	55.5
40	76.3	76.0	75.3	74.6	74.0
50	95.4	95.0	94.1	93.3	92.5

	110	110	109	108
6	11.0	11.0	10.9	10.8
7	12.9	12.8	12.7	12.6
8	14.7	14.6	14.5	14.4
9	16.6	16.5	16.3	16.2
10	18.4	18.3	18.1	18.0
20	36.8	36.6	36.3	36.0
30	55.2	55.0	54.5	54.0
40	73.6	73.3	72.6	72.0
50	92.1	91.6	90.8	90.0

	107	107	106	105	104
6	10.7	10.7	10.6	10.5	10.4
7	12.5	12.5	12.3	12.2	12.1
8	14.3	14.2	14.1	14.0	13.8
9	16.1	16.0	15.9	15.7	15.6
10	17.9	17.8	17.6	17.5	17.3
20	35.8	35.6	35.3	35.0	34.6
30	53.7	53.5	53.0	52.5	52.0
40	71.6	71.3	70.6	70.0	69.3
50	89.6	89.1	88.3	87.5	86.6

	103	103	2	1	1
6	10.3	10.3	0.2	0.1	0.1
7	12.1	12.0	0.2	0.2	0.1
8	13.8	13.7	0.2	0.2	0.1
9	15.6	15.4	0.3	0.2	0.1
10	17.2	17.1	0.3	0.2	0.1
20	34.5	34.3	0.6	0.5	0.3
30	51.7	51.5	1.0	0.7	0.5
40	69.0	68.6	1.3	1.0	0.6
50	86.2	85.8	1.6	1.2	0.8

P. P.

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.	
0	9·08 589	102	9·08 914	104	0·91 085	9·99 675	60
1	9·08 692	102	9·09 018	104	0·90 981	9·99 673	59
2	9·08 794	102	9·09 123	103	0·90 877	9·99 672	58
3	9·08 897	102	9·09 226	103	0·90 774	9·99 670	57
4	9·08 999	102	9·09 330	103	0·90 670	9·99 669	56
5	9·09 101	102	9·09 433	103	0·90 566	9·99 667	55
6	9·09 202	101	9·09 536	103	0·90 463	9·99 665	54
7	9·09 303	101	9·09 639	103	0·90 360	9·99 664	53
8	9·09 404	101	9·09 742	102	0·90 258	9·99 662	52
9	9·09 505	101	9·09 844	102	0·90 155	9·99 661	51
10	9·09 606	100	9·09 947	102	0·90 053	9·99 659	50
11	9·09 706	100	9·10 048	101	0·89 951	9·99 658	49
12	9·09 806	100	9·10 150	102	0·89 849	9·99 656	48
13	9·09 906	100	9·10 252	101	0·89 748	9·99 654	47
14	9·10 006	99	9·10 353	101	0·89 647	9·99 653	46
15	9·10 105	99	9·10 454	101	0·89 546	9·99 651	45
16	9·10 205	98	9·10 555	101	0·89 445	9·99 650	44
17	9·10 303	99	9·10 655	100	0·89 344	9·99 648	43
18	9·10 402	98	9·10 756	100	0·89 244	9·99 646	42
19	9·10 501	98	9·10 856	100	0·89 144	9·99 645	41
20	9·10 599	98	9·10 956	100	0·89 044	9·99 643	40
21	9·10 697	98	9·11 055	99	0·88 944	9·99 641	39
22	9·10 795	97	9·11 155	99	0·88 845	9·99 640	38
23	9·10 892	97	9·11 254	99	0·88 745	9·99 638	37
24	9·10 990	97	9·11 353	99	0·88 64	9·99 637	36
25	9·11 087	96	9·11 452	98	0·88 548	9·99 635	35
26	9·11 184	97	9·11 550	98	0·88 449	9·99 63	34
27	9·11 281	96	9·11 649	98	0·88 351	9·99 632	33
28	9·11 377	96	9·11 747	98	0·88 253	9·99 630	32
29	9·11 473	96	9·11 845	98	0·88 155	9·99 628	31
30	9·11 570	95	9·11 943	98	0·88 057	9·99 627	30
31	9·11 665	95	9·12 040	97	0·87 959	9·99 625	29
32	9·11 761	95	9·12 137	97	0·87 862	9·99 623	28
33	9·11 856	95	9·12 235	97	0·87 765	9·99 622	27
34	9·11 952	95	9·12 331	96	0·87 668	9·99 620	26
35	9·12 047	95	9·12 428	97	0·87 571	9·99 618	25
36	9·12 141	94	9·12 525	96	0·87 475	9·99 617	24
37	9·12 236	94	9·12 621	96	0·87 379	9·99 615	23
38	9·12 330	94	9·12 717	96	0·87 283	9·99 613	22
39	9·12 425	94	9·12 813	96	0·87 187	9·99 611	21
40	9·12 518	93	9·12 908	95	0·87 091	9·99 610	20
41	9·12 612	94	9·13 004	95	0·86 996	9·99 608	19
42	9·12 706	93	9·13 099	95	0·86 900	9·99 606	18
43	9·12 799	93	9·13 194	95	0·86 805	9·99 605	17
44	9·12 892	93	9·13 289	95	0·86 710	9·99 603	16
45	9·12 985	93	9·13 384	94	0·86 616	9·99 601	15
46	9·13 078	93	9·13 478	94	0·86 521	9·99 600	14
47	9·13 170	92	9·13 572	94	0·86 427	9·99 598	13
48	9·13 263	93	9·13 666	94	0·86 333	9·99 596	12
49	9·13 355	92	9·13 760	93	0·86 239	9·99 594	11
50	9·13 447	92	9·13 854	93	0·86 146	9·99 593	10
51	9·13 538	91	9·13 947	93	0·86 052	9·99 591	9
52	9·13 630	92	9·14 041	93	0·85 959	9·99 589	8
53	9·13 721	91	9·14 134	93	0·85 866	9·99 587	7
54	9·13 813	91	9·14 227	93	0·85 773	9·99 586	6
55	9·13 903	90	9·14 315	92	0·85 685	9·99 584	5
56	9·13 994	91	9·14 412	92	0·85 588	9·99 582	4
57	9·14 085	90	9·14 504	92	0·85 495	9·99 580	3
58	9·14 175	90	9·14 596	92	0·85 403	9·99 579	2
59	9·14 265	90	9·14 688	92	0·85 311	9·99 577	1
60	9·14 355	90	9·14 780	92	0·85 219	9·99 575	0
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	′

P. P.				
	104	103	102	101
6	10·4	10·3	10·2	10·1
7	12·1	12·0	11·9	11·8
8	13·8	13·7	13·6	13·4
9	15·6	15·4	15·3	15·1
10	17·3	17·1	17·0	16·8
20	34·6	34·3	34·0	33·6
30	52·0	51·5	51·0	50·5
40	69·3	68·6	68·0	67·3
50	86·6	85·8	85·0	84·1

P. P.				
	100	100	99	98
6	10·0	10·0	9·9	9·8
7	11·7	11·6	11·5	11·4
8	13·4	13·3	13·2	13·0
9	15·1	15·0	14·8	14·7
10	16·7	16·6	16·5	16·3
20	33·5	33·3	33·0	32·6
30	50·2	50·0	49·5	49·0
40	67·0	66·6	66·0	65·3
50	83·7	83·3	82·5	81·6

P. P.				
	97	97	96	95
6	9·7	9·7	9·6	9·5
7	11·4	11·3	11·2	11·1
8	13·0	12·9	12·8	12·6
9	14·6	14·5	14·4	14·2
10	16·2	16·1	16·0	15·8
20	32·5	32·3	32·0	31·6
30	48·7	48·5	48·0	47·5
40	65·0	64·6	64·0	63·3
50	81·2	80·8	80·0	79·1

P. P.				
	94	94	93	92
6	9·4	9·4	9·3	9·2
7	11·0	10·9	10·8	10·7
8	12·6	12·5	12·4	12·2
9	14·2	14·1	13·9	13·8
10	15·7	15·6	15·5	15·3
20	31·5	31·3	31·0	30·6
30	47·2	47·0	46·5	46·0
40	63·0	62·6	62·0	61·3
50	78·7	78·3	77·5	76·6

P. P.				
	91	91	90	2
6	9·1	9·1	9·0	0·2
7	10·7	10·6	10·5	0·2
8	12·2	12·1	12·0	0·2
9	13·7	13·6	13·5	0·3
10	15·2	15·1	15·0	0·3
20	30·5	30·3	30·0	0·6
30	45·7	45·5	45·0	1·0
40	61·0	60·6	60·0	1·3
50	76·2	75·8	75·0	1·6

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.		P. P.
0	9.14 355		9.14 780		0.85 219	9.99 575	60	
1	9.14 445	90	9.14 872	91	0.85 128	9.99 573	59	
2	9.14 535	89	9.14 963	91	0.85 037	9.99 571	58	91 91 90 89
3	9.14 624	89	9.15 054	91	0.84 945	9.99 570	57	6 9.1 9.1 9.0 8.9
4	9.14 713	89	9.15 145	91	0.84 854	9.99 568	56	7 10.7 10.6 10.5 10.4
5	9.14 802	89	9.15 236	91	0.84 763	9.99 566	55	8 12.2 12.1 12.0 11.8
6	9.14 891	89	9.15 327	90	0.84 673	9.99 564	54	9 13.7 13.6 13.5 13.3
7	9.14 980	88	9.15 417	90	0.84 582	9.99 563	53	10 15.2 15.1 15.0 14.8
8	9.15 068	88	9.15 507	90	0.84 492	9.99 561	52	20 30.5 30.3 30.0 29.6
9	9.15 157	88	9.15 598	90	0.84 402	9.99 559	51	30 45.7 45.5 45.0 44.5
10	9.15 245	88	9.15 687	89	0.84 312	9.99 557	50	40 61.0 60.6 60.0 59.3
11	9.15 333	88	9.15 777	90	0.84 222	9.99 555	49	50 76.2 75.8 75.0 74.1
12	9.15 421	88	9.15 867	89	0.84 133	9.99 553	48	
13	9.15 508	87	9.15 956	89	0.84 043	9.99 552	47	
14	9.15 595	87	9.16 045	89	0.83 954	9.99 550	46	
15	9.15 683	87	9.16 134	89	0.83 865	9.99 548	45	88 88 87 86
16	9.15 770	87	9.16 223	89	0.83 776	9.99 546	44	6 8.8 8.8 8.7 8.6
17	9.15 857	87	9.16 312	89	0.83 687	9.99 544	43	7 10.3 10.2 10.1 10.0
18	9.15 943	86	9.16 401	88	0.83 599	9.99 542	42	8 11.8 11.7 11.6 11.4
19	9.16 030	86	9.16 489	88	0.83 511	9.99 541	41	9 13.3 13.2 13.0 12.9
20	9.16 116	86	9.16 577	88	0.83 422	9.99 539	40	10 14.7 14.6 14.5 14.3
21	9.16 202	86	9.16 665	88	0.83 334	9.99 537	39	20 29.5 29.3 29.0 28.6
22	9.16 288	86	9.16 753	87	0.83 247	9.99 535	38	30 44.2 44.0 43.5 43.0
23	9.16 374	86	9.16 841	88	0.83 159	9.99 533	37	40 59.0 58.6 58.0 57.3
24	9.16 460	85	9.16 928	87	0.83 071	9.99 531	36	50 73.7 73.3 72.5 71.6
25	9.16 545	85	9.17 015	87	0.82 984	9.99 529	35	
26	9.16 630	85	9.17 103	87	0.82 897	9.99 528	34	85 85 84 83
27	9.16 716	85	9.17 190	87	0.82 810	9.99 526	33	6 8.5 8.5 8.4 8.3
28	9.16 801	85	9.17 276	86	0.82 723	9.99 524	32	7 10.0 9.9 9.8 9.7
29	9.16 885	84	9.17 363	87	0.82 636	9.99 522	31	8 11.4 11.3 11.2 11.0
30	9.16 970	85	9.17 450	86	0.82 550	9.99 520	30	9 12.8 12.7 12.6 12.4
31	9.17 054	84	9.17 536	86	0.82 464	9.99 518	29	10 14.2 14.1 14.0 13.8
32	9.17 139	84	9.17 622	86	0.82 377	9.99 516	28	20 28.5 28.3 28.0 27.6
33	9.17 223	84	9.17 708	86	0.82 291	9.99 514	27	30 42.7 42.5 42.0 41.5
34	9.17 307	84	9.17 794	85	0.82 206	9.99 512	26	40 57.0 56.6 56.0 55.3
35	9.17 391	84	9.17 8 0	86	0.82 120	9.99 511	25	50 71.2 70.8 70.0 69.1
36	9.17 474	83	9.17 965	85	0.82 034	9.99 509	24	
37	9.17 558	83	9.18 051	85	0.81 949	9.99 507	23	
38	9.17 641	83	9.18 136	85	0.81 864	9.99 505	22	
39	9.17 724	83	9.18 221	85	0.81 779	9.99 503	21	82 82 81 80
40	9.17 807	83	9.18 306	84	0.81 694	9.99 501	20	6 8.2 8.2 8.1 8.0
41	9.17 890	83	9.18 390	84	0.81 609	9.99 499	19	7 9.6 9.5 9.4 9.3
42	9.17 972	82	9.18 475	84	0.81 525	9.99 497	18	8 11.0 10.9 10.8 10.6
43	9.18 055	82	9.18 559	84	0.81 440	9.99 495	17	9 12.4 12.3 12.1 12.0
44	9.18 137	82	9.18 644	84	0.81 356	9.99 493	16	10 13.7 13.6 13.5 13.3
45	9.18 219	82	9.18 728	84	0.81 272	9.99 491	15	20 27.5 27.3 27.0 26.6
46	9.18 301	82	9.18 812	84	0.81 188	9.99 489	14	30 41.2 41.0 40.5 40.0
47	9.18 383	82	9.18 896	83	0.81 104	9.99 487	13	40 55.0 54.6 54.0 53.3
48	9.18 465	81	9.18 979	83	0.81 020	9.99 485	12	50 68.7 68.3 67.5 66.6
49	9.18 546	81	9.19 063	83	0.80 937	9.99 484	11	
50	9.18 628	81	9.19 146	83	0.80 854	9.99 482	10	79 2 1
51	9.18 709	81	9.19 229	83	0.80 770	9.99 480	9	6 7.9 0.2 0.1
52	9.18 790	81	9.19 312	83	0.80 687	9.99 478	8	7 9.3 0.2 0.2
53	9.18 871	80	9.19 395	82	0.80 604	9.99 476	7	8 10.6 0.2 0.2
54	9.18 952	81	9.19 478	82	0.80 522	9.99 474	6	9 11.9 0.3 0.2
55	9.19 033	80	9.19 560	82	0.80 439	9.99 472	5	10 13.2 0.3 0.2
56	9.19 113	80	9.19 643	82	0.80 357	9.99 470	4	20 26.5 0.6 0.5
57	9.19 193	80	9.19 725	82	0.80 274	9.99 468	3	30 39.7 1.0 0.7
58	9.19 273	80	9.19 807	82	0.80 192	9.99 466	2	40 53.0 1.3 1.0
59	9.19 353	79	9.19 889	82	0.80 110	9.99 464	1	50 66.2 1.6 1.2
60	9.19 433		9.19 971		0.80 028	9.99 462	0	
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	′	P. P.

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.	
0	9.19 433	80	9.19 971	81	0.80 028	9.99 462	60
1	9.19 513	79	9.20 053	81	0.79 947	9.99 460	59
2	9.19 592	79	9.20 134	81	0.79 865	9.99 458	58
3	9.19 672	79	9.20 216	81	0.79 784	9.99 456	57
4	9.19 751	79	9.20 297	81	0.79 703	9.99 454	56
5	9.19 830	79	9.20 378	81	0.79 622	9.99 452	55
6	9.19 909	79	9.20 459	81	0.79 541	9.99 450	54
7	9.19 988	79	9.20 540	81	0.79 460	9.99 448	53
8	9.20 066	78	9.20 620	80	0.79 379	9.99 446	52
9	9.20 145	78	9.20 701	81	0.79 298	9.99 444	51
10	9.20 223	78	9.20 781	80	0.79 218	9.99 442	50
11	9.20 301	78	9.20 862	80	0.79 138	9.99 440	49
12	9.20 379	78	9.20 942	80	0.79 058	9.99 437	48
13	9.20 457	78	9.21 022	80	0.78 978	9.99 435	47
14	9.20 535	77	9.21 102	79	0.78 898	9.99 433	46
15	9.20 613	77	9.21 181	79	0.78 818	9.99 431	45
16	9.20 690	77	9.21 261	79	0.78 739	9.99 428	44
17	9.20 768	77	9.21 340	79	0.78 659	9.99 427	43
18	9.20 845	77	9.21 420	79	0.78 580	9.99 425	42
19	9.20 922	77	9.21 499	79	0.78 501	9.99 423	41
20	9.20 999	77	9.21 578	79	0.78 422	9.99 421	40
21	9.21 076	76	9.21 657	78	0.78 343	9.99 419	39
22	9.21 152	76	9.21 735	78	0.78 264	9.99 417	38
23	9.21 229	76	9.21 814	78	0.78 186	9.99 415	37
24	9.21 305	76	9.21 892	78	0.78 107	9.99 413	36
25	9.21 382	76	9.21 971	78	0.78 029	9.99 411	35
26	9.21 458	76	9.22 049	78	0.77 951	9.99 408	34
27	9.21 534	75	9.22 127	78	0.77 873	9.99 406	33
28	9.21 609	75	9.22 205	78	0.77 795	9.99 404	32
29	9.21 685	76	9.22 283	78	0.77 717	9.99 402	31
30	9.21 761	75	9.22 360	77	0.77 639	9.99 400	30
31	9.21 836	75	9.22 438	77	0.77 562	9.99 398	29
32	9.21 911	75	9.22 515	77	0.77 484	9.99 396	28
33	9.21 987	75	9.22 593	77	0.77 407	9.99 394	27
34	9.22 062	74	9.22 670	77	0.77 330	9.99 392	26
35	9.22 136	75	9.22 747	77	0.77 253	9.99 389	25
36	9.22 211	74	9.22 824	76	0.77 176	9.99 387	24
37	9.22 286	74	9.22 900	77	0.77 099	9.99 385	23
38	9.22 360	74	9.22 977	76	0.77 022	9.99 383	22
39	9.22 435	74	9.23 054	76	0.76 946	9.99 381	21
40	9.22 509	74	9.23 130	76	0.76 870	9.99 379	20
41	9.22 583	74	9.23 206	76	0.76 793	9.99 377	19
42	9.22 657	74	9.23 282	76	0.76 717	9.99 374	18
43	9.22 731	73	9.23 358	76	0.76 641	9.99 372	17
44	9.22 805	74	9.23 434	76	0.76 565	9.99 370	16
45	9.22 878	73	9.23 510	76	0.76 489	9.99 368	15
46	9.22 952	73	9.23 586	75	0.76 414	9.99 366	14
47	9.23 025	73	9.23 661	75	0.76 338	9.99 364	13
48	9.23 098	73	9.23 737	75	0.76 263	9.99 361	12
49	9.23 171	73	9.23 812	75	0.76 188	9.99 359	11
50	9.23 244	73	9.23 887	75	0.76 113	9.99 357	10
51	9.23 317	72	9.23 962	75	0.76 038	9.99 355	9
52	9.23 390	73	9.24 037	75	0.75 963	9.99 353	8
53	9.23 462	72	9.24 112	74	0.75 888	9.99 350	7
54	9.23 535	72	9.24 186	74	0.75 813	9.99 348	6
55	9.23 607	72	9.24 261	74	0.75 739	9.99 346	5
56	9.23 679	72	9.24 335	74	0.75 664	9.99 344	4
57	9.23 751	72	9.24 409	74	0.75 590	9.99 342	3
58	9.23 823	72	9.24 484	74	0.75 516	9.99 339	2
59	9.23 895	71	9.24 558	74	0.75 442	9.99 337	1
60	9.23 967		9.24 632	74	0.75 368	9.99 335	0
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	′

P. P.

	81	81	80	79
6	8.1	8.1	8.0	7.9
7	9.5	9.4	9.3	9.2
8	10.8	10.8	10.6	10.5
9	12.2	12.1	12.0	11.8
10	13.6	13.5	13.3	13.1
20	27.1	27.0	26.6	26.3
30	40.7	40.5	40.0	39.5
40	54.3	54.0	53.3	52.6
50	67.9	67.5	66.6	65.8

	78	78	77
6	7.8	7.8	7.7
7	9.1	9.1	9.0
8	10.4	10.4	10.2
9	11.8	11.7	11.5
10	13.1	13.0	12.8
20	26.1	26.0	25.6
30	39.2	39.0	38.5
40	52.3	52.0	51.3
50	65.4	65.0	64.1

	76	76	75	74
6	7.6	7.6	7.5	7.4
7	8.9	8.8	8.7	8.6
8	10.2	10.1	10.0	9.8
9	11.5	11.4	11.2	11.1
10	12.7	12.6	12.5	12.3
20	25.5	25.3	25.0	24.6
30	38.2	38.0	37.5	37.0
40	51.0	50.6	50.0	49.3
50	63.7	63.3	62.5	61.6

	73	73	72
6	7.3	7.3	7.2
7	8.6	8.5	8.4
8	9.8	9.7	9.6
9	11.0	10.9	10.8
10	12.2	12.1	12.0
20	24.5	24.3	24.0
30	36.7	36.5	36.0
40	49.0	48.6	48.0
50	61.2	60.8	60.0

	71	71	2	2
6	7.1	7.1	0.2	0.2
7	8.3	8.3	0.2	0.2
8	9.5	9.4	0.3	0.2
9	10.7	10.6	0.4	0.3
10	11.9	11.8	0.4	0.3
20	23.8	23.6	0.8	0.6
30	35.7	35.5	1.2	1.0
40	47.6	47.3	1.6	1.3
50	59.6	59.1	2.1	1.6

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.		′
0	9·23 967	7$\bar{1}$	9·24 632	73	0·75 368	9·99 335	60	60
1	9·24 038	7$\bar{1}$	9·24 705	73	0·75 294	9·99 333	59	59
2	9·24 110	7$\bar{1}$	9·24 779	73	0·75 220	9·99 330	58	58
3	9·24 181	71	9·24 853	73	0·75 147	9·99 328	57	57
4	9·24 252	71	9·24 926	73	0·75 073	9·99 326	56	56
5	9·24 323	71	9·25 000	73	0·75 000	9·99 324	55	55
6	9·24 394	71	9·25 073	73	0·74 927	9·99 321	54	54
7	9·24 465	71	9·25 146	73	0·74 854	9·99 319	53	53
8	9·24 536	70	9·25 219	73	0·74 781	9·99 317	52	52
9	9·24 607	70	9·25 292	73	0·74 708	9·99 315	51	51
10	9·24 677	70	9·25 365	73	0·74 635	9·99 312	50	50
11	9·24 748	70	9·25 437	72	0·74 562	9·99 310	49	49
12	9·24 818	70	9·25 510	72	0·74 490	9·99 308	48	48
13	9·24 888	70	9·25 582	72	0·74 417	9·99 306	47	47
14	9·24 958	69	9·25 654	72	0·74 345	9·99 303	46	46
15	9·25 028	70	9·25 727	72	0·74 273	9·99 301	45	45
16	9·25 098	69	9·25 799	72	0·74 201	9·99 299	44	44
17	9·25 167	70	9·25 871	72	0·74 129	9·99 296	43	43
18	9·25 237	69	9·25 943	71	0·74 057	9·99 294	42	42
19	9·25 306	69	9·26 014	72	0·73 985	9·99 292	41	41
20	9·25 376	69	9·26 086	71	0·73 913	9·99 290	40	40
21	9·25 445	69	9·26 158	71	0·73 842	9·99 287	39	39
22	9·25 514	69	9·26 229	71	0·73 771	9·99 285	38	38
23	9·25 583	69	9·26 300	71	0·73 699	9·99 283	37	37
24	9·25 652	68	9·26 371	71	0·73 628	9·99 280	36	36
25	9·25 721	69	9·26 443	71	0·73 557	9·99 278	35	35
26	9·25 790	68	9·26 514	70	0·73 486	9·99 276	34	34
27	9·25 858	68	9·26 584	71	0·73 415	9·99 273	33	33
28	9·25 927	68	9·26 655	70	0·73 344	9·99 271	32	32
29	9·25 995	68	9·26 726	70	0·73 274	9·99 269	31	31
30	9·26 063	68	9·26 796	70	0·73 203	9·99 266	30	30
31	9·26 131	68	9·26 867	70	0·73 133	9·99 264	29	29
32	9·26 199	68	9·26 937	70	0·73 062	9·99 262	28	28
33	9·26 267	67	9·27 007	70	0·72 992	9·99 259	27	27
34	9·26 335	67	9·27 078	70	0·72 922	9·99 257	26	26
35	9·26 402	68	9·27 148	70	0·72 852	9·99 255	25	25
36	9·26 470	67	9·27 218	69	0·72 782	9·99 252	24	24
37	9·26 537	67	9·27 287	70	0·72 712	9·99 250	23	23
38	9·26 605	67	9·27 357	69	0·72 642	9·99 248	22	22
39	9·26 672	67	9·27 427	70	0·72 573	9·99 245	21	21
40	9·26 739	67	9·27 496	69	0·72 503	9·99 243	20	20
41	9·26 806	67	9·27 566	69	0·72 434	9·99 240	19	19
42	9·26 873	66	9·27 635	69	0·72 365	9·99 238	18	18
43	9·26 940	67	9·27 704	69	0·72 295	9·99 236	17	17
44	9·27 007	66	9·27 773	69	0·72 226	9·99 233	16	16
45	9·27 073	66	9·27 842	69	0·72 157	9·99 231	15	15
46	9·27 140	66	9·27 911	68	0·72 088	9·99 228	14	14
47	9·27 206	66	9·27 980	69	0·72 020	9·99 226	13	13
48	9·27 272	66	9·28 049	68	0·71 951	9·99 224	12	12
49	9·27 339	66	9·28 117	68	0·71 882	9·99 221	11	11
50	9·27 405	66	9·28 186	68	0·71 814	9·99 219	10	10
51	9·27 471	65	9·28 254	68	0·71 746	9·99 216	9	9
52	9·27 536	66	9·28 322	68	0·71 677	9·99 214	8	8
53	9·27 602	65	9·28 390	68	0·71 609	9·99 212	7	7
54	9·27 668	66	9·28 459	68	0·71 541	9·99 209	6	6
55	9·27 733	65	9·28 527	67	0·71 473	9·99 207	5	5
56	9·27 799	65	9·28 594	68	0·71 405	9·99 204	4	4
57	9·27 864	65	9·28 662	67	0·71 337	9·99 202	3	3
58	9·27 929	65	9·28 730	67	0·71 270	9·99 199	2	2
59	9·27 995	65	9·28 797	67	0·71 202	9·99 197	1	1
60	9·28 060		9·28 865		0·71 135	9·99 194	0	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.		′

P. P.

	74	73	73
6	7.4	7.3	7.3
7	8.6	8.6	8.5
8	9.8	9.8	9.7
9	11.1	11.0	10.9
10	12.3	12.2	12.1
20	24.6	24.5	24.3
30	37.0	36.7	36.5
40	49.3	49.0	48.6
50	61.6	61.2	60.8

	72	72	71	71
6	7.2	7.2	7.1	7.1
7	8.4	8.4	8.3	8.3
8	9.6	9.6	9.5	9.4
9	10.9	10.8	10.7	10.6
10	12.1	12.0	11.9	11.8
20	24.1	24.0	23.8	23.6
30	36.2	36.0	35.7	35.5
40	48.3	48.0	47.6	47.3
50	60.4	60.0	59.6	59.1

	70	70	69	69
6	7.0	7.0	6.9	6.9
7	8.2	8.1	8.1	8.0
8	9.4	9.3	9.2	9.2
9	10.6	10.5	10.4	10.3
10	11.7	11.6	11.6	11.5
20	23.5	23.3	23.1	23.0
30	35.2	35.0	34.7	34.5
40	47.0	46.6	46.3	46.0
50	58.7	58.3	57.9	57.5

	68	68	67	67
6	6.8	6.8	6.7	6.7
7	8.0	7.9	7.9	7.8
8	9.1	9.0	9.0	8.9
9	10.3	10.2	10.1	10.0
10	11.4	11.3	11.2	11.1
20	22.8	22.6	22.5	22.3
30	34.2	34.0	33.7	33.5
40	45.6	45.3	45.0	44.6
50	57.1	56.6	56.2	55.8

	66	66	65	65
6	6.6	6.6	6.5	6.5
7	7.7	7.7	7.6	7.6
8	8.8	8.8	8.7	8.6
9	10.0	9.9	9.8	9.7
10	11.1	11.0	10.9	10.8
20	22.1	22.0	21.8	21.6
30	33.2	33.0	32.7	32.5
40	44.3	44.0	43.6	43.3
50	55.4	55.0	54.6	54.1

	2	2
6	0.2	0.2
7	0.3	0.2
8	0.3	0.2
9	0.4	0.3
10	0.4	0.3
20	0.8	0.6
30	1.2	1.0
40	1.6	1.3
50	2.1	1.6

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	
0	9.28 060	65	9.28 865	67	0.71 135	9.99 194	60
1	9.28 125	64	9.28 932	67	0.71 067	9.99 192	59
2	9.28 189	65	9.29 000	67	0.71 000	9.99 189	58
3	9.28 254	64	9.29 067	67	0.70 933	9.99 187	57
4	9.28 319	64	9.29 134	67	0.70 866	9.99 185	56
5	9.28 383	64	9.29 201	67	0.70 798	9.99 182	55
6	9.28 448	64	9.29 268	66	0.70 732	9.99 180	54
7	9.28 512	64	9.29 335	67	0.70 665	9.99 177	53
8	9.28 576	64	9.29 401	66	0.70 598	9.99 175	52
9	9.28 641	64	9.29 468	67	0.70 531	9.99 172	51
10	9.28 705	64	9.29 535	66	0.70 465	9.99 170	50
11	9.28 769	63	9.29 601	66	0.70 398	9.99 167	49
12	9.28 832	64	9.29 667	66	0.70 332	9.99 165	48
13	9.28 896	63	9.29 734	66	0.70 266	9.99 162	47
14	9.28 960	63	9.29 800	66	0.70 200	9.99 160	46
15	9.29 023	63	9.29 866	66	0.70 134	9.99 157	45
16	9.29 087	63	9.29 932	66	0.70 068	9.99 155	44
17	9.29 150	63	9.29 998	66	0.70 002	9.99 152	43
18	9.29 213	63	9.30 064	65	0.69 936	9.99 150	42
19	9.29 277	63	9.30 129	66	0.69 870	9.99 147	41
20	9.29 340	63	9.30 195	65	0.69 805	9.99 145	40
21	9.29 403	63	9.30 260	65	0.69 739	9.99 142	39
22	9.29 466	63	9.30 326	65	0.69 674	9.99 139	38
23	9.29 528	62	9.30 391	65	0.69 608	9.99 137	37
24	9.29 591	63	9.30 456	65	0.69 543	9.99 134	36
25	9.29 654	62	9.30 522	65	0.69 478	9.99 132	35
26	9.29 716	62	9.30 587	65	0.69 413	9.99 129	34
27	9.29 779	62	9.30 652	65	0.69 348	9.99 127	33
28	9.29 841	62	9.30 717	64	0.69 283	9.99 124	32
29	9.29 903	62	9.30 781	64	0.69 218	9.99 122	31
30	9.29 965	62	9.30 846	65	0.69 153	9.99 119	30
31	9.30 027	62	9.30 911	64	0.69 089	9.99 116	29
32	9.30 089	62	9.30 975	64	0.69 024	9.99 114	28
33	9.30 151	62	9.31 040	64	0.68 960	9.99 111	27
34	9.30 213	61	9.31 104	64	0.68 896	9.99 109	26
35	9.30 275	62	9.31 168	64	0.68 831	9.99 106	25
36	9.30 336	61	9.31 232	64	0.68 767	9.99 104	24
37	9.30 398	62	9.31 297	64	0.68 703	9.99 101	23
38	9.30 459	61	9.31 361	63	0.68 639	9.99 098	22
39	9.30 520	61	9.31 424	63	0.68 575	9.99 096	21
40	9.30 582	61	9.31 488	64	0.68 511	9.99 093	20
41	9.30 643	61	9.31 552	63	0.68 447	9.99 091	19
42	9.30 704	61	9.31 616	63	0.68 384	9.99 088	18
43	9.30 765	61	9.31 679	63	0.68 320	9.99 085	17
44	9.30 826	61	9.31 743	63	0.68 257	9.99 083	16
45	9.30 886	60	9.31 806	63	0.68 193	9.99 080	15
46	9.30 947	61	9.31 869	63	0.68 130	9.99 077	14
47	9.31 008	60	9.31 933	63	0.68 067	9.99 075	13
48	9.31 068	60	9.31 996	63	0.68 004	9.99 072	12
49	9.31 129	60	9.32 059	63	0.67 941	9.99 069	11
50	9.31 189	60	9.32 122	63	0.67 878	9.99 067	10
51	9.31 249	60	9.32 185	63	0.67 815	9.99 064	9
52	9.31 309	60	9.32 248	62	0.67 752	9.99 062	8
53	9.31 370	60	9.32 310	63	0.67 689	9.99 059	7
54	9.31 429	59	9.32 373	62	0.67 626	9.99 056	6
55	9.31 489	60	9.32 436	62	0.67 564	9.99 054	5
56	9.31 549	59	9.32 498	62	0.67 501	9.99 051	4
57	9.31 609	60	9.32 560	62	0.67 439	9.99 048	3
58	9.31 669	59	9.32 623	62	0.67 377	9.99 046	2
59	9.31 728	59	9.32 685	62	0.67 314	9.99 043	1
60	9.31 788	59	9.32 747	62	0.67 252	9.99 040	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	′

P. P.

	67	67		
6	6·7	6·7		
7	7·9	7·8		
8	9·0	8·9		
9	10·1	10·0		
10	11·2	11·1		
20	22·5	22·3		
30	33·7	33·5		
40	45·0	44·6		
50	56·2	55·8		

	66	66	65	65
6	6·6	6·6	6·5	6·5
7	7·7	7·7	7·6	7·6
8	8·8	8·8	8·7	8·6
9	10·0	9·9	9·8	9·7
10	11·1	11·0	10·9	10·8
20	22·1	22·0	21·8	21·6
30	33·2	33·0	32·7	32·5
40	44·3	44·0	43·6	43·3
50	55·4	55·0	54·6	54·1

	64	64	63	63
6	6·4	6·4	6·3	6·3
7	7·5	7·4	7·4	7·3
8	8·6	8·5	8·4	8·4
9	9·7	9·6	9·5	9·4
10	10·7	10·6	10·6	10·5
20	21·5	21·3	21·1	21·0
30	32·2	32·0	31·7	31·5
40	43·0	42·6	42·3	42·0
50	53·7	53·3	52·9	52·5

	62	62	61	61
6	6·2	6·2	6·1	6·1
7	7·3	7·2	7·2	7·1
8	8·3	8·2	8·2	8·1
9	9·4	9·3	9·2	9·1
10	10·4	10·3	10·2	10·1
20	20·8	20·6	20·5	20·3
30	31·2	31·0	30·7	30·5
40	41·6	41·3	41·0	40·6
50	52·1	51·6	51·2	50·8

	60	60	59	
6	6·0	6·0	5·9	
7	7·0	7·0	6·9	
8	8·0	8·0	7·9	
9	9·1	9·0	8·9	
10	10·1	10·0	9·9	
20	20·1	20·0	19·8	
30	30·2	30·0	29·7	
40	40·3	40·0	39·6	
50	50·4	50·0	49·6	

	3	2	2
6	0·3	0·2	0·2
7	0·3	0·2	0·2
8	0·4	0·3	0·2
9	0·4	0·4	0·3
10	0·5	0·4	0·3
20	1·0	0·8	0·6
30	1·5	1·2	1·0
40	2·0	1·6	1·3
50	2·5	2·1	1·6

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	
0	9·31 788	59	9·32 747	62	0·67 252	9·99 040	60
1	9·31 847	59	9·32 809	62	0·67 190	9·99 038	59
2	9·31 906	59	9·32 871	62	0·67 128	9·99 035	58
3	9·31 966	59	9·32 933	62	0·67 066	9·99 032	57
4	9·32 025	59	9·32 995	61	0·67 004	9·99 029	56
5	9·32 084	59	9·33 057	61	0·66 943	9·99 027	55
6	9·32 143	59	9·33 118	61	0·66 881	9·99 024	54
7	9·32 202	58	9·33 180	62	0·66 819	9·99 021	53
8	9·32 260	59	9·33 242	61	0·66 758	9·99 019	52
9	9·32 319	58	9·33 303	61	0·66 696	9·99 016	51
10	9·32 378	58	9·33 364	61	0·66 635	9·99 013	50
11	9·32 436	58	9·33 426	61	0·66 574	9·99 010	49
12	9·32 495	58	9·33 487	61	0·66 513	9·99 008	48
13	9·32 553	58	9·33 548	61	0·66 452	9·99 005	47
14	9·32 611	58	9·33 609	60	0·66 390	9·99 002	46
15	9·32 670	58	9·33 670	61	0·66 330	9·98 999	45
16	9·32 728	58	9·33 731	61	0·66 269	9·98 997	44
17	9·32 786	58	9·33 792	60	0·66 208	9·98 994	43
18	9·32 844	58	9·33 852	61	0·66 147	9·98 991	42
19	9·32 902	58	9·33 913	60	0·66 086	9·98 988	41
20	9·32 960	57	9·33 974	60	0·66 026	9·98 986	40
21	9·33 017	58	9·34 034	60	0·65 965	9·98 983	39
22	9·33 075	57	9·34 095	60	0·65 905	9·98 980	38
23	9·33 133	57	9·34 155	60	0·65 845	9·98 977	37
24	9·33 190	57	9·34 215	60	0·65 784	9·98 975	36
25	9·33 248	57	9·34 275	60	0·65 724	9·98 972	35
26	9·33 305	57	9·34 336	60	0·65 664	9·98 969	34
27	9·33 362	57	9·34 396	60	0·65 604	9·98 966	33
28	9·33 419	57	9·34 456	59	0·65 544	9·98 963	32
29	9·33 476	57	9·34 515	60	0·65 484	9·98 961	31
30	9·33 533	57	9·34 575	60	0·65 424	9·98 958	30
31	9·33 590	57	9·34 635	59	0·65 364	9·98 955	29
32	9·33 647	57	9·34 695	59	0·65 305	9·98 952	28
33	9·33 704	56	9·34 754	59	0·65 245	9·98 949	27
34	9·33 761	57	9·34 814	59	0·65 186	9·98 947	26
35	9·33 817	56	9·34 873	59	0·65 126	9·98 944	25
36	9·33 874	57	9·34 933	59	0·65 067	9·98 941	24
37	9·33 930	56	9·34 992	59	0·65 008	9·98 938	23
38	9·33 987	56	9·35 051	59	0·64 948	9·98 935	22
39	9·34 043	56	9·35 110	59	0·64 889	9·98 933	21
40	9·34 099	56	9·35 169	59	0·64 830	9·98 930	20
41	9·34 156	56	9·35 228	59	0·64 771	9·98 927	19
42	9·34 212	56	9·35 287	59	0·64 712	9·98 924	18
43	9·34 268	56	9·35 346	59	0·64 653	9·98 921	17
44	9·34 324	56	9·35 405	59	0·64 594	9·98 918	16
45	9·34 379	55	9·35 464	58	0·64 536	9·98 915	15
46	9·34 435	56	9·35 522	59	0·64 477	9·98 913	14
47	9·34 491	55	9·35 581	58	0·64 418	9·98 910	13
48	9·34 547	56	9·35 640	58	0·64 360	9·98 907	12
49	9·34 602	55	9·35 698	58	0·64 302	9·98 904	11
50	9·34 658	55	9·35 756	58	0·64 243	9·98 901	10
51	9·34 713	55	9·35 815	58	0·64 185	9·98 898	9
52	9·34 768	55	9·35 873	58	0·64 127	9·98 895	8
53	9·34 824	55	9·35 931	58	0·64 068	9·98 892	7
54	9·34 879	55	9·35 989	58	0·64 010	9·98 890	6
55	9·34 934	55	9·36 047	58	0·63 952	9·98 887	5
56	9·34 989	55	9·36 105	58	0·63 894	9·98 884	4
57	9·35 044	54	9·36 163	57	0·63 837	9·98 881	3
58	9·35 099	55	9·36 221	58	0·63 779	9·98 878	2
59	9·35 154	55	9·36 278	57	0·63 721	9·98 875	1
60	9·35 209		9·36 336	58	0·63 663	9·98 872	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	′

P. P.

	62	61	61
6	6·2	6·1	6·1
7	7·2	7·2	7·1
8	8·2	8·2	8·1
9	9·3	9·2	9·1
10	10·3	10·2	10·1
20	20·6	20·5	20·3
30	31·0	30·7	30·5
40	41·3	41·0	40·6
50	51·6	51·2	50·8

	60	60	59	59
6	6·0	6·0	5·9	5·9
7	7·0	7·0	6·9	6·9
8	8·0	8·0	7·9	7·8
9	9·1	9·0	8·9	8·8
10	10·1	10·0	9·9	9·8
20	20·1	20·0	19·8	19·6
30	30·2	30·0	29·7	29·5
40	40·3	40·0	39·6	39·3
50	50·4	50·0	49·6	49·1

	58	58	57	57
6	5·8	5·8	5·7	5·7
7	6·8	6·7	6·7	6·6
8	7·8	7·7	7·6	7·6
9	8·8	8·7	8·6	8·5
10	9·7	9·6	9·6	9·5
20	19·5	19·3	19·1	19·0
30	29·2	29·0	28·7	28·5
40	39·0	38·6	38·3	38·0
50	48·7	48·3	47·9	47·5

	56	56	55	55
6	5·6	5·6	5·5	5·5
7	6·6	6·5	6·5	6·4
8	7·5	7·4	7·4	7·3
9	8·5	8·4	8·3	8·2
10	9·4	9·3	9·2	9·1
20	18·8	18·6	18·5	18·3
30	28·2	28·0	27·7	27·5
40	37·6	37·3	37·0	36·6
50	47·1	46·6	46·2	45·8

	54	3	2
6	5·4	0·3	0·2
7	6·3	0·3	0·3
8	7·2	0·4	0·3
9	8·2	0·4	0·4
10	9·1	0·5	0·4
20	18·1	1·0	0·8
30	27·2	1·5	1·2
40	36·3	2·0	1·6
50	45·4	2·5	2·1

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	
0	9.35 209	54	9.36 336	57	0.63 663	9.98 872	60
1	9.35 263	54	9 36 394	57	0 63 606	9.98 869	59
2	9.35 318	54	9.36 451	57	0.63 548	9.98 866	58
3	9.35 372	54	9.36 509	57	0.63 491	9.98 863	57
4	9.35 427	54	9.36 566	57	0.63 433	9.98 860	56
5	9.35 481	54	9.36 623	57	0.63 376	9.98 858	55
6	9.35 536	54	9.36 681	57	0.63 319	9.98 855	54
7	9.35 590	54	9.36 738	57	0.63 262	9.98 852	53
8	9.35 644	54	9.36 795	57	0.63 204	9.98 849	52
9	9.35 698	54	9.36 852	57	0.63 147	9.98 846	51
10	9.35 752	54	9.36 909	57	0.63 090	9.98 843	50
11	9.35 806	54	9.36 966	56	0.63 033	9.98 840	49
12	9.35 860	53	9.37 023	57	0.62 977	9.98 837	48
13	9.35 914	54	9.37 080	56	0.62 920	9.98 834	47
14	9.35 968	53	9.37 136	57	0.62 863	9.98 831	46
15	9.36 021	53	9.37 193	56	0.62 806	9.98 828	45
16	9.36 075	53	9.37 250	56	0.62 750	9.98 825	44
17	9.36 128	53	9.37 306	56	0.62 693	9.98 822	43
18	9.36 182	53	9.37 363	56	0.62 637	9.98 819	42
19	9.36 235	53	9.37 419	56	0.62 580	9.98 816	41
20	9.36 289	53	9.37 475	56	0.62 524	9.98 813	40
21	9.36 342	53	9.37 532	56	0.62 468	9.98 810	39
22	9.36 395	53	9.37 588	56	0.62 412	9.98 807	38
23	9.36 448	53	9.37 644	56	0.62 356	9.98 804	37
24	9.36 501	53	9.37 700	56	0.62 299	9.98 801	36
25	9.36 554	53	9.37 756	56	0.62 243	9.98 798	35
26	9.36 607	53	9.37 812	56	0.62 188	9.98 795	34
27	9.36 660	53	9.37 868	56	0.62 132	9.98 792	33
28	9.36 713	53	9.37 924	55	0.62 076	9.98 789	32
29	9.36 766	53	9.37 979	56	0.62 020	9.98 786	31
30	9.36 818	52	9.38 035	56	0.61 964	9.98 783	30
31	9.36 871	52	9.38 091	55	0.61 909	9.98 780	29
32	9.36 923	52	9.38 146	56	0.61 853	9.98 777	28
33	9.36 976	52	9.38 202	55	0.61 798	9.98 774	27
34	9.37 028	52	9.38 257	55	0.61 742	9.98 771	26
35	9.37 081	52	9.38 313	55	0.61 687	9.98 768	25
36	9.37 133	52	9.38 368	55	0.61 632	9.98 765	24
37	9.37 185	52	9.38 423	55	0.61 576	9.98 762	23
38	9.37 237	52	9.38 478	55	0.61 521	9.98 759	22
39	9.37 289	52	9.38 533	55	0.61 466	9.98 755	21
40	9.37 341	52	9.38 589	55	0.61 411	9.98 752	20
41	9.37 393	52	9.38 644	54	0.61 356	9.98 749	19
42	9.37 445	52	9.38 698	55	0.61 301	9.98 746	18
43	9.37 497	51	9.38 753	55	0.61 246	9.98 743	17
44	9.37 548	52	9.38 808	54	0.61 191	9.98 740	16
45	9.37 600	52	9.38 863	55	0.61 137	9.98 737	15
46	9.37 652	51	9.38 918	54	0.61 082	9.98 734	14
47	9.37 703	52	9.38 972	54	0.61 027	9.98 731	13
48	9.37 755	51	9.39 027	54	0.60 973	9.98 728	12
49	9.37 806	51	9.39 081	54	0.60 918	9.98 725	11
50	9.37 857	51	9.39 136	54	0.60 864	9.98 721	10
51	9.37 909	51	9.39 190	54	0.60 809	9.98 718	9
52	9.37 960	51	9.39 244	54	0.60 755	9.98 715	8
53	9.38 011	51	9.39 299	54	0.60 701	9.98 712	7
54	9.38 062	51	9.39 353	54	0.60 647	9.98 709	6
55	9.38 113	51	9.39 407	54	0.60 592	9.98 706	5
56	9.38 164	51	9.39 461	54	0.60 538	9.98 703	4
57	9.38 215	50	9.39 515	54	0.60 484	9.98 700	3
58	9.38 266	51	9.39 569	54	0.60 430	9.98 696	2
59	9.38 317	50	9.39 623	53	0.60 376	9.98 693	1
60	9.38 367		9.39 677		0.60 323	9.98 690	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	′

P. P.

	57	57	56	56
6	5.7	5.7	5.6	5.6
7	6.7	6.6	6.6	6.5
8	7.6	7.6	7.5	7.4
9	8.6	8.5	8.5	8.4
10	9.6	9.5	9.4	9.3
20	19.1	19.0	18.8	18.6
30	28.7	28.5	28.2	28.0
40	38.3	38.0	37.6	37.3
50	47.9	47.5	47.1	46.6

	55	55	54	54
6	5.5	5.5	5.4	5.4
7	6.5	6.4	6.3	6.3
8	7.4	7.3	7.2	7.2
9	8.3	8.2	8.2	8.1
10	9.2	9.1	9.1	9.0
20	18.5	18.3	18.1	18.0
30	27.7	27.5	27.2	27.0
40	37.0	36.6	36.3	36.0
50	46.2	45.8	45.4	45.0

	53	53	52	52
6	5.3	5.3	5.2	5.2
7	6.2	6.2	6.1	6.0
8	7.1	7.0	7.0	6.9
9	8.0	7.9	7.9	7.8
10	8.9	8.8	8.7	8.6
20	17.8	17.6	17.5	17.3
30	26.7	26.5	26.2	26.0
40	35.6	35.3	35.0	34.6
50	44.6	44.1	43.7	43.3

	51	51	50
6	5.1	5.1	5.0
7	6.0	5.9	5.9
8	6.8	6.8	6.7
9	7.7	7.6	7.6
10	8.6	8.5	8.4
20	17.1	17.0	16.8
30	25.7	25.5	25.2
40	34.3	34.0	33.6
50	42.9	42.5	42.1

	3	3	2
6	0.3	0.3	0.2
7	0.4	0.3	0.3
8	0.4	0.4	0.3
9	0.5	0.4	0.4
10	0.6	0.5	0.4
20	1.1	1.0	0.8
30	1.7	1.5	1.2
40	2.3	2.0	1.6
50	2.9	2.5	2.1

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
0	9.38 367	50	9.39 677	54	0.60 323	9.98 690	3	60
1	9.38 418	50	9.39 731	53	0.60 269	9.98 687	3	59
2	9.38 468	50	9.39 784	54	0.60 215	9.98 684	3	58
3	9.38 519	50	9.39 838	53	0.60 161	9.98 681	3	57
4	9.38 569	50	9.39 892	53	0.60 108	9.98 678	3	56
5	9.38 620	50	9.39 945	53	0.60 054	9.98 674	3	55
6	9.38 670	50	9.39 999	53	0.60 001	9.98 671	3	54
7	9.38 720	50	9.40 052	53	0.59 947	9.98 668	3	53
8	9.38 771	50	9.40 106	53	0.59 894	9.98 665	3	52
9	9.38 821	50	9.40 159	53	0.59 841	9.98 662	3	51
10	9.38 871	50	9.40 212	53	0.59 787	9.98 658	3	50
11	9.38 921	50	9.40 265	53	0.59 734	9.98 655	3	49
12	9.38 971	50	9.40 318	53	0.59 681	9.98 652	3	48
13	9.39 021	50	9.40 372	53	0.59 628	9.98 649	3	47
14	9.39 071	49	9.40 425	53	0.59 575	9.98 646	3	46
15	9.39 120	50	9.40 478	53	0.59 522	9.98 642	3	45
16	9.39 170	49	9.40 531	53	0.59 469	9.98 639	3	44
17	9.39 220	49	9.40 583	52	0.59 416	9.98 636	3	43
18	9.39 269	49	9.40 636	53	0.59 363	9.98 633	3	42
19	9.39 319	49	9.40 689	52	0.59 311	9.98 630	3	41
20	9.39 368	49	9.40 742	53	0.59 258	9.98 626	3	40
21	9.39 418	49	9.40 794	52	0.59 205	9.98 623	3	39
22	9.39 467	49	9.40 847	53	0.59 153	9.98 620	3	38
23	9.39 516	49	9.40 899	52	0.59 100	9.98 617	3	37
24	9.39 566	49	9.40 952	52	0.59 048	9.98 613	3	36
25	9.39 615	49	9.41 004	52	0.58 995	9.98 610	3	35
26	9.39 664	49	9.41 057	52	0.58 943	9.98 607	3	34
27	9.39 713	49	9.41 109	52	0.58 891	9.98 604	3	33
28	9.39 762	49	9.41 161	52	0.58 838	9.98 600	3	32
29	9.39 811	49	9.41 213	52	0.58 786	9.98 597	3	31
30	9.39 860	49	9.41 266	52	0.58 734	9.98 594	3	30
31	9.39 909	49	9.41 318	52	0.58 682	9.98 591	3	29
32	9.39 957	48	9.41 370	52	0.58 630	9.98 587	3	28
33	9.40 006	49	9.41 422	52	0.58 578	9.98 584	3	27
34	9.40 055	48	9.41 474	52	0.58 526	9.98 581	3	26
35	9.40 103	48	9.41 525	51	0.58 474	9.98 578	3	25
36	9.40 152	48	9.41 577	52	0.58 422	9.98 574	3	24
37	9.40 200	48	9.41 629	52	0.58 370	9.98 571	3	23
38	9.40 249	48	9.41 681	51	0.58 319	9.98 568	3	22
39	9.40 297	48	9.41 732	51	0.58 267	9.98 564	3	21
40	9.40 345	48	9.41 784	52	0.58 216	9.98 561	3	20
41	9.40 394	48	9.41 836	52	0.58 164	9.98 558	3	19
42	9.40 442	48	9.41 887	51	0.58 112	9.98 554	3	18
43	9.40 490	48	9.41 938	51	0.58 061	9.98 551	3	17
44	9.40 538	48	9.41 990	51	0.58 010	9.98 548	3	16
45	9.40 586	48	9.42 041	51	0.57 958	9.98 544	3	15
46	9.40 634	48	9.42 093	51	0.57 907	9.98 541	3	14
47	9.40 682	48	9.42 144	51	0.57 856	9.98 538	3	13
48	9.40 730	47	9.42 195	51	0.57 805	9.98 534	3	12
49	9.40 777	48	9.42 246	51	0.57 753	9.98 531	3	11
50	9.40 825	47	9.42 297	51	0.57 702	9.98 528	3	10
51	9.40 873	47	9.42 348	51	0.57 651	9.98 524	3	9
52	9.40 920	47	9.42 399	51	0.57 600	9.98 521	3	8
53	9.40 968	47	9.42 450	50	0.57 549	9.98 518	3	7
54	9.41 015	47	9.42 501	51	0.57 499	9.98 514	3	6
55	9.41 063	47	9.42 552	50	0.57 448	9.98 511	3	5
56	9.41 110	47	9.42 602	51	0.57 397	9.98 508	3	4
57	9.41 158	47	9.42 653	50	0.57 346	9.98 504	3	3
58	9.41 205	47	9.42 704	50	0.57 296	9.98 501	3	2
59	9.41 252	47	9.42 754	50	0.57 245	9.98 498	3	1
60	9.41 299	47	9.42 805	50	0.57 195	9.98 494	3	0
′	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	54	53	53
6	5.4	5.3	5.3
7	6.3	6.2	6.2
8	7.2	7.1	7.0
9	8.1	8.0	7.9
10	9.0	8.9	8.8
20	18.0	17.8	17.6
30	27.0	26.7	26.5
40	36.0	35.6	35.3
50	45.0	44.6	44.1

	52	52	51	51
6	5.2	5.2	5.1	5.1
7	6.1	6.0	6.0	5.9
8	7.0	6.9	6.8	6.8
9	7.9	7.8	7.7	7.6
10	8.7	8.6	8.6	8.5
20	17.5	17.3	17.1	17.0
30	26.2	26.0	25.7	25.5
40	35.0	34.6	34.3	34.0
50	43.7	43.3	42.9	42.5

	50	50	49	49
6	5.0	5.0	4.9	4.9
7	5.9	5.8	5.8	5.7
8	6.7	6.6	6.6	6.5
9	7.6	7.5	7.4	7.3
10	8.4	8.3	8.2	8.1
20	16.8	16.6	16.5	16.3
30	25.2	25.0	24.7	24.5
40	33.6	33.3	33.0	32.6
50	42.1	41.6	41.2	40.8

	48	48	47	47
6	4.8	4.8	4.7	4.7
7	5.6	5.6	5.5	5.5
8	6.4	6.4	6.3	6.2
9	7.3	7.2	7.1	7.0
10	8.1	8.0	7.9	7.8
20	16.1	16.0	15.8	15.6
30	24.2	24.0	23.7	23.5
40	32.3	32.0	31.6	31.3
50	40.4	40.0	39.6	39.1

	3	3
6	0.3	0.3
7	0.4	0.3
8	0.4	0.4
9	0.5	0.4
10	0.6	0.5
20	1.1	1.0
30	1.7	1.5
40	2.3	2.0
50	2.9	2.5

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9.41 299	47	9.42 805	51	0.57 195	9.98 494	1	60
1	9.41 346	47	9.42 856	50	0.57 144	9.98 491	1	59
2	9.41 394	47	9.42 906	50	0.57 094	9.98 487	1	58
3	9.41 441	47	9.42 956	50	0.57 043	9.98 484	1	57
4	9.41 488	46	9.43 007	50	0.56 993	9.98 481	1	56
5	9.41 534	47	9.43 057	50	0.56 942	9.98 477	1	55
6	9.41 581	47	9.43 107	50	0.56 892	9.98 474	1	54
7	9.41 628	46	9.43 157	50	0.56 842	9.98 470	1	53
8	9.41 675	46	9.43 208	50	0.56 792	9.98 467	1	52
9	9.41 721	46	9.43 258	50	0.56 742	9.98 464	1	51
10	9.41 768	47	9.43 308	50	0.56 692	9.98 460	1	50
11	9.41 815	46	9.43 358	50	0.56 642	9.98 457	1	49
12	9.41 861	46	9.43 408	50	0.56 592	9.98 453	1	48
13	9.41 908	46	9.43 458	50	0.56 542	9.98 450	1	47
14	9.41 954	46	9.43 508	50	0.56 492	9.98 446	1	46
15	9.42 000	46	9.43 557	49	0.56 442	9.98 443	1	45
16	9.42 047	46	9.43 607	50	0.56 392	9.98 439	1	44
17	9.42 093	46	9.43 657	50	0.56 343	9.98 436	1	43
18	9.42 139	46	9.43 706	49	0.56 293	9.98 433	1	42
19	9.42 185	46	9.43 756	50	0.56 243	9.98 429	1	41
20	9.42 232	46	9.43 806	49	0.56 194	9.98 426	1	40
21	9.42 278	46	9.43 855	49	0.56 144	9.98 422	1	39
22	9.42 324	45	9.43 905	49	0.56 095	9.98 419	1	38
23	9.42 369	46	9.43 954	49	0.56 045	9.98 415	1	37
24	9.42 415	46	9.44 003	49	0.55 996	9.98 412	1	36
25	9.42 461	46	9.44 053	49	0.55 947	9.98 408	1	35
26	9.42 507	46	9.44 102	49	0.55 898	9.98 405	1	34
27	9.42 553	45	9.44 151	49	0.55 848	9.98 401	1	33
28	9.42 598	45	9.44 200	49	0.55 799	9.98 398	1	32
29	9.42 644	46	9.44 249	49	0.55 750	9.98 394	1	31
30	9.42 690	45	9.44 299	49	0.55 701	9.98 391	1	30
31	9.42 735	45	9.44 348	49	0.55 652	9.98 387	1	29
32	9.42 781	45	9.44 397	49	0.55 603	9.98 384	1	28
33	9.42 826	45	9.44 446	49	0.55 554	9.98 380	1	27
34	9.42 871	45	9.44 494	48	0.55 505	9.98 377	1	26
35	9.42 917	45	9.44 543	49	0.55 456	9.98 373	1	25
36	9.42 962	45	9.44 592	49	0.55 407	9.98 370	1	24
37	9.43 007	45	9.44 641	49	0.55 359	9.98 366	1	23
38	9.43 052	45	9.44 690	49	0.55 310	9.98 363	1	22
39	9.43 098	44	9.44 738	48	0.55 261	9.98 359	1	21
40	9.43 143	45	9.44 787	48	0.55 213	9.98 356	1	20
41	9.43 188	45	9.44 835	48	0.55 164	9.98 352	1	19
42	9.43 233	45	9.44 884	48	0.55 116	9.98 348	1	18
43	9.43 278	44	9.44 932	48	0.55 067	9.98 345	1	17
44	9.43 322	44	9.44 981	48	0.55 019	9.98 341	1	16
45	9.43 367	45	9.45 029	48	0.54 970	9.98 338	1	15
46	9.43 412	44	9.45 077	48	0.54 922	9.98 334	1	14
47	9.43 457	45	9.45 126	48	0.54 874	9.98 331	1	13
48	9.43 501	44	9.45 174	48	0.54 825	9.98 327	1	12
49	9.43 546	44	9.45 222	48	0.54 777	9.98 324	1	11
50	9.43 591	45	9.45 270	48	0.54 729	9.98 320	1	10
51	9.43 635	44	9.45 318	48	0.54 681	9.98 316	1	9
52	9.43 680	44	9.45 367	48	0.54 633	9.98 313	1	8
53	9.43 724	44	9.45 415	48	0.54 585	9.98 309	1	7
54	9.43 768	44	9.45 463	48	0.54 537	9.98 306	1	6
55	9.43 813	44	9.45 510	47	0.54 489	9.98 302	1	5
56	9.43 857	44	9.45 558	48	0.54 441	9.98 298	1	4
57	9.43 901	44	9.45 606	48	0.54 393	9.98 295	1	3
58	9.43 945	44	9.45 654	47	0.54 346	9.98 291	1	2
59	9.43 989	44	9.45 702	48	0.54 298	9.98 288	1	1
60	9.44 034	44	9.45 749	47	0.54 250	9.98 284	1	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	5̄0	50		
6	5.0	5.0		
7	5.9	5.8		
8	6.7	6.6		
9	7.6	7.5		
10	8.4	8.3		
20	16.8	16.6		
30	25.2	25.0		
40	33.6	33.3		
50	42.1	41.6		

	4̄9	49	4̄8	48
6	4.9	4.9	4.8	4.8
7	5.8	5.7	5.6	5.6
8	6.6	6.5	6.4	6.4
9	7.4	7.3	7.3	7.2
10	8.2	8.1	8.1	8.0
20	16.5	16.3	16.1	16.0
30	24.7	24.5	24.2	24.0
40	33.0	32.6	32.3	32.0
50	41.2	40.8	40.4	40.0

	4̄7	47	4̄6	46
6	4.7	4.7	4.6	4.6
7	5.5	5.5	5.4	5.4
8	6.3	6.2	6.2	6.1
9	7.1	7.0	7.0	6.9
10	7.9	7.8	7.7	7.7
20	15.8	15.6	15.5	15.3
30	23.7	23.5	23.2	23.0
40	31.6	31.3	31.0	30.6
50	39.6	39.1	38.7	38.3

	4̄5	45	4̄4	44
6	4.5	4.5	4.4	4.4
7	5.3	5.2	5.2	5.1
8	6.0	6.0	5.9	5.8
9	6.8	6.7	6.7	6.6
10	7.6	7.5	7.4	7.3
20	15.1	15.0	14.8	14.7
30	22.7	22.5	22.2	22.0
40	30.3	30.0	29.6	29.3
50	37.9	37.5	37.1	36.7

	4	3̄	3	
6	0.4	0.3	0.3	
7	0.4	0.4	0.3	
8	0.5	0.4	0.4	
9	0.6	0.5	0.4	
10	0.6	0.6	0.5	
20	1.3	1.1	1.0	
30	2.0	1.7	1.5	
40	2.6	2.3	2.0	
50	3.3	2.9	2.5	

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
0	9.44 034	44	9.45 749	48	0.54 250	9.98 284	4	60
1	9.44 078	44	9.45 797	47	0.54 203	9.98 280	5	59
2	9.44 122	44	9.45 845	47	0.54 155	9.98 277	5	58
3	9.44 166	43	9.45 892	47	0.54 107	9.98 273	4	57
4	9.44 209	44	9.45 940	47	0.54 060	9.98 269	5	56
5	9.44 253	44	9.45 987	47	0.54 012	9.98 266	4	55
6	9.44 297	43	9.46 035	47	0.53 965	9.98 262	5	54
7	9.44 341	43	9.46 082	47	0.53 917	9.98 258	4	53
8	9.44 384	44	9.46 129	47	0.53 870	9.98 255	5	52
9	9.44 428	43	9.46 177	47	0.53 823	9.98 251	4	51
10	9.44 472	43	9.46 224	47	0.53 776	9.98 247	4	50
11	9.44 515	43	9.46 271	47	0.53 728	9.98 244	5	49
12	9.44 559	43	9.46 318	47	0.53 681	9.98 240	4	48
13	9.44 602	43	9.46 366	47	0.53 634	9.98 236	4	47
14	9.44 646	43	9.46 413	47	0.53 587	9.98 233	5	46
15	9.44 689	43	9.46 460	47	0.53 540	9.98 229	4	45
16	9.44 732	43	9.46 507	47	0.53 493	9.98 225	4	44
17	9.44 776	43	9.46 554	47	0.53 446	9.98 222	5	43
18	9.44 819	43	9.46 601	47	0.53 399	9.98 218	4	42
19	9.44 862	43	9.46 647	46	0.53 352	9.98 214	4	41
20	9.44 905	43	9.46 694	47	0.53 305	9.98 211	3	40
21	9.44 948	43	9.46 741	47	0.53 258	9.98 207	4	39
22	9.44 991	43	9.46 788	46	0.53 212	9.98 203	4	38
23	9.45 034	43	9.46 834	46	0.53 165	9.98 200	4	37
24	9.45 077	43	9.46 881	47	0.53 118	9.98 196	4	36
25	9.45 120	43	9.46 928	46	0.53 072	9.98 192	3	35
26	9.45 163	42	9.46 974	46	0.53 025	9.98 188	4	34
27	9.45 206	43	9.47 021	46	0.52 979	9.98 185	4	33
28	9.45 249	43	9.47 067	46	0.52 932	9.98 181	3	32
29	9.45 291	42	9.47 114	46	0.52 886	9.98 177	4	31
30	9.45 334	42	9.47 160	46	0.52 839	9.98 173	4	30
31	9.45 377	43	9.47 207	46	0.52 793	9.98 170	3	29
32	9.45 419	42	9.47 253	46	0.52 747	9.98 166	4	28
33	9.45 462	43	9.47 299	46	0.52 700	9.98 162	4	27
34	9.45 504	42	9.47 345	46	0.52 654	9.98 158	4	26
35	9.45 547	42	9.47 392	46	0.52 608	9.98 155	3	25
36	9.45 589	42	9.47 438	46	0.52 562	9.98 151	4	24
37	9.45 631	42	9.47 484	46	0.52 516	9.98 147	4	23
38	9.45 674	42	9.47 530	46	0.52 469	9.98 143	3	22
39	9.45 716	42	9.47 576	46	0.52 423	9.98 140	4	21
40	9.45 758	42	9.47 622	46	0.52 377	9.98 136	4	20
41	9.45 800	42	9.47 668	46	0.52 331	9.98 132	4	19
42	9.45 842	42	9.47 714	46	0.52 286	9.98 128	4	18
43	9.45 885	42	9.47 760	46	0.52 240	9.98 124	3	17
44	9.45 927	42	9.47 806	46	0.52 194	9.98 121	4	16
45	9.45 969	42	9.47 851	45	0.52 148	9.98 117	4	15
46	9.46 011	41	9.47 897	46	0.52 102	9.98 113	4	14
47	9.46 052	42	9.47 943	46	0.52 057	9.98 109	3	13
48	9.46 094	42	9.47 989	46	0.52 011	9.98 105	3	12
49	9.46 136	41	9.48 034	45	0.51 965	9.98 102	4	11
50	9.46 178	42	9.48 080	45	0.51 920	9.98 098	4	10
51	9.46 220	41	9.48 125	45	0.51 874	9.98 094	4	9
52	9.46 261	42	9.48 171	45	0.51 829	9.98 090	4	8
53	9.46 303	41	9.48 216	45	0.51 783	9.98 086	4	7
54	9.46 345	42	9.48 262	45	0.51 738	9.98 082	4	6
55	9.46 386	41	9.48 307	45	0.51 692	9.98 079	3	5
56	9.46 428	41	9.48 353	45	0.51 647	9.98 075	4	4
57	9.46 469	41	9.48 398	45	0.51 602	9.98 071	4	3
58	9.46 511	41	9.48 443	45	0.51 556	9.98 067	4	2
59	9.46 552	41	9.48 488	45	0.51 511	9.98 063	4	1
60	9.46 593	41	9.48 534	45	0.51 466	9.98 059	4	0
′	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	48	47	47
6	4.8	4.7	4.7
7	5.6	5.5	5.5
8	6.4	6.3	6.2
9	7.2	7.1	7.0
10	8.0	7.9	7.8
20	16.0	15.8	15.6
30	24.0	23.7	23.5
40	32.0	31.6	31.3
50	40.0	39.6	39.1

	46	46	45	45
6	4.6	4.6	4.5	4.5
7	5.4	5.3	5.3	5.2
8	6.2	6.1	6.0	6.0
9	7.0	6.9	6.8	6.7
10	7.7	7.6	7.6	7.5
20	15.5	15.3	15.1	15.0
30	23.2	23.0	22.7	22.5
40	31.0	30.6	30.3	30.0
50	38.7	38.3	37.9	37.5

	44	43	43
6	4.4	4.3	4.3
7	5.1	5.1	5.0
8	5.8	5.8	5.7
9	6.6	6.5	6.4
10	7.3	7.2	7.1
20	14.6	14.5	14.3
30	22.0	21.7	21.5
40	29.3	29.0	28.6
50	36.6	36.2	35.8

	42	42	41	41
6	4.2	4.2	4.1	4.1
7	4.9	4.9	4.8	4.8
8	5.6	5.6	5.5	5.4
9	6.4	6.3	6.2	6.1
10	7.1	7.0	6.9	6.8
20	14.1	14.0	13.8	13.6
30	21.2	21.0	20.7	20.5
40	28.3	28.0	27.6	27.3
50	35.4	35.0	34.6	34.1

	4	3
6	0.4	0.3
7	0.4	0.4
8	0.5	0.4
9	0.6	0.5
10	0.6	0.6
20	1.3	1.1
30	2.0	1.7
40	2.6	2.3
50	3.3	2.9

P. P.

17°

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9.46 593	41	9.48 534	45	0.51 466	9.98 059	3	60
1	9.46 635	41	9.48 579	45	0.51 421	9.98 056	4	59
2	9.46 676	41	9.48 624	45	0.51 376	9.98 052	4	58
3	9.46 717	41	9.48 669	45	0.51 330	9.98 048	4	57
4	9.46 758	41	9.48 714	45	0.51 285	9.98 044	4	56
5	9.46 799	41	9.48 759	45	0.51 240	9.98 040	4	55
6	9.46 840	41	9.48 804	44	0.51 195	9.98 036	4	54
7	9.46 881	41	9.48 849	45	0.51 151	9.98 032	4	53
8	9.46 922	41	9.48 894	45	0.51 106	9.98 028	4	52
9	9.46 963	41	9.48 939	45	0.51 061	9.98 024	4	51
10	9.47 004	41	9.48 984	45	0.51 016	9.98 021	3	50
11	9.47 045	41	9.49 028	44	0.50 971	9.98 017	4	49
12	9.47 086	40	9.49 073	44	0.50 926	9.98 013	4	48
13	9.47 127	41	9.49 118	44	0.50 882	9.98 009	4	47
14	9.47 168	41	9.49 162	44	0.50 837	9.98 005	4	46
15	9.47 208	40	9.49 207	45	0.50 792	9.98 001	4	45
16	9.47 249	40	9.49 252	44	0.50 748	9.97 997	4	44
17	9.47 290	41	9.49 296	44	0.50 703	9.97 993	4	43
18	9.47 330	40	9.49 341	44	0.50 659	9.97 989	4	42
19	9.47 371	40	9.49 385	44	0.50 614	9.97 985	4	41
20	9.47 411	40	9.49 430	44	0.50 570	9.97 981	4	40
21	9.47 452	40	9.49 474	44	0.50 525	9.97 977	4	39
22	9.47 492	40	9.49 518	44	0.50 481	9.97 973	4	38
23	9.47 532	40	9.49 563	44	0.50 437	9.97 969	4	37
24	9.47 573	40	9.49 607	44	0.50 392	9.97 966	4	36
25	9.47 613	40	9.49 651	44	0.50 348	9.97 962	4	35
26	9.47 653	40	9.49 695	44	0.50 304	9.97 958	4	34
27	9.47 694	40	9.49 740	44	0.50 260	9.97 954	4	33
28	9.47 734	40	9.49 784	44	0.50 216	9.97 950	4	32
29	9.47 774	40	9.49 828	44	0.50 172	9.97 946	4	31
30	9.47 814	40	9.49 872	44	0.50 128	9.97 942	4	30
31	9.47 854	40	9.49 916	44	0.50 083	9.97 938	4	29
32	9.47 894	40	9.49 960	43	0.50 039	9.97 934	4	28
33	9.47 934	40	9.50 004	44	0.49 996	9.97 930	4	27
34	9.47 974	40	9.50 048	44	0.49 952	9.97 926	4	26
35	9.48 014	40	9.50 092	44	0.49 908	9.97 922	4	25
36	9.48 054	40	9.50 136	44	0.49 864	9.97 918	4	24
37	9.48 093	39	9.50 179	43	0.49 820	9.97 914	4	23
38	9.48 133	40	9.50 223	44	0.49 776	9.97 910	4	22
39	9.48 173	39	9.50 267	43	0.49 733	9.97 906	4	21
40	9.48 213	40	9.50 311	44	0.49 689	9.97 902	4	20
41	9.48 252	39	9.50 354	43	0.49 645	9.97 898	4	19
42	9.48 292	39	9.50 398	44	0.49 602	9.97 894	4	18
43	9.48 331	39	9.50 442	43	0.49 558	9.97 890	4	17
44	9.48 371	39	9.50 485	43	0.49 514	9.97 886	4	16
45	9.48 410	39	9.50 529	43	0.49 471	9.97 881	4	15
46	9.48 450	39	9.50 572	43	0.49 427	9.97 877	4	14
47	9.48 489	39	9.50 616	43	0.49 384	9.97 873	4	13
48	9.48 529	39	9.50 659	43	0.49 340	9.97 869	4	12
49	9.48 568	39	9.50 702	43	0.49 297	9.97 865	4	11
50	9.48 607	39	9.50 746	43	0.49 254	9.97 861	4	10
51	9.48 646	39	9.50 789	43	0.49 210	9.97 857	4	9
52	9.48 686	39	9.50 832	43	0.49 167	9.97 853	4	8
53	9.48 725	39	9.50 876	43	0.49 124	9.97 849	4	7
54	9.48 764	39	9.50 919	43	0.49 081	9.97 845	4	6
55	9.48 803	39	9.50 962	43	0.49 038	9.97 841	4	5
56	9.48 842	39	9.51 005	43	0.48 994	9.97 837	4	4
57	9.48 881	39	9.51 048	43	0.48 951	9.97 833	4	3
58	9.48 920	39	9.51 091	43	0.48 908	9.97 829	4	2
59	9.48 959	39	9.51 134	43	0.48 865	9.97 824	4	1
60	9.48 998	38	9.51 177	43	0.48 822	9.97 820	4	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	45	45	44	44
6	4.5	4.5	4.4	4.4
7	5.3	5.2	5.2	5.1
8	6.0	6.0	5.9	5.8
9	6.8	6.7	6.7	6.6
10	7.6	7.5	7.4	7.3
20	15.1	15.0	14.8	14.6
30	22.7	22.5	22.2	22.0
40	30.3	30.0	29.6	29.3
50	37.9	37.5	37.1	36.6

P. P.

	43	43
6	4.3	4.3
7	5.1	5.0
8	5.8	5.7
9	6.5	6.4
10	7.2	7.1
20	14.5	14.3
30	21.7	21.5
40	29.0	28.6
50	36.2	35.8

P. P.

	41	41	40	40
6	4.1	4.1	4.0	4.0
7	4.8	4.8	4.7	4.6
8	5.5	5.4	5.4	5.3
9	6.2	6.1	6.1	6.0
10	6.9	6.8	6.7	6.6
20	13.8	13.6	13.5	13.3
30	20.7	20.5	20.2	20.0
40	27.6	27.3	27.0	26.6
50	34.6	34.1	33.7	33.3

P. P.

	39	39	38
6	3.9	3.9	3.8
7	4.6	4.5	4.5
8	5.2	5.2	5.1
9	5.9	5.8	5.8
10	6.6	6.5	6.4
20	13.1	13.0	12.8
30	19.7	19.5	19.2
40	26.3	26.0	25.6
50	32.9	32.5	32.1

P. P.

	4	4	3
6	0.4	0.4	0.3
7	0.5	0.4	0.4
8	0.6	0.5	0.4
9	0.7	0.6	0.5
10	0.7	0.6	0.6
20	1.5	1.3	1.1
30	2.2	2.0	1.7
40	3.0	2.6	2.3
50	3.7	3.3	2.9

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
0	9.48 998		9.51 177		0.48 822	9.97 820		60
1	9.49 037	39	9.51 220	43	0.48 779	9.97 816	4	59
2	9.49 076	39	9.51 263	43	0.48 735	9.97 812	4	58
3	9.49 114	38	9.51 306	43	0.48 693	9.97 808	4	57
4	9.49 153	39	9.51 349	43	0.48 650	9.97 804	4	56
5	9.49 192	38	9.51 392	42	0.48 608	9.97 800	4	55
6	9.49 231	39	9.51 435	42	0.48 565	9.97 796	4	54
7	9.49 269	38	9.51 477	42	0.48 522	9.97 792	4	53
8	9.49 308	38	9.51 520	43	0.48 479	9.97 787	4	52
9	9.49 346	38	9.51 563	42	0.48 437	9.97 783	4	51
10	9.49 385	38	9.51 605	42	0.48 394	9.97 779	4	50
11	9.49 423	38	9.51 648	43	0.48 351	9.97 775	4	49
12	9.49 462	38	9.51 691	42	0.48 309	9.97 771	4	48
13	9.49 500	38	9.51 733	42	0.48 266	9.97 767	4	47
14	9.49 539	38	9.51 776	42	0.48 224	9.97 763	4	46
15	9.49 577	38	9.51 818	42	0.48 181	9.97 758	4	45
16	9.49 615	38	9.51 861	42	0.48 139	9.97 754	4	44
17	9.49 653	38	9.51 903	42	0.48 096	9.97 750	4	43
18	9.49 692	38	9.51 946	42	0.48 054	9.97 746	4	42
19	9.49 730	38	9.51 988	42	0.48 012	9.97 742	4	41
20	9.49 768	38	9.52 030	42	0.47 969	9.97 737	4	40
21	9.49 806	38	9.52 073	42	0.47 927	9.97 733	4	39
22	9.49 844	38	9.52 115	42	0.47 885	9.97 729	4	38
23	9.49 882	38	9.52 157	42	0.47 842	9.97 725	4	37
24	9.49 920	38	9.52 199	42	0.47 800	9.97 721	4	36
25	9.49 958	38	9.52 241	42	0.47 758	9.97 716	4	35
26	9.49 996	37	9.52 284	42	0.47 716	9.97 712	4	34
27	9.50 034	38	9.52 326	42	0.47 674	9.97 708	4	33
28	9.50 072	38	9.52 368	42	0.47 632	9.97 704	4	32
29	9.50 110	38	9.52 410	42	0.47 590	9.97 700	4	31
30	9.50 147	37	9.52 452	42	0.47 548	9.97 695	4	30
31	9.50 185	38	9.52 494	42	0.47 506	9.97 691	4	29
32	9.50 223	37	9.52 536	42	0.47 464	9.97 687	4	28
33	9.50 260	38	9.52 578	41	0.47 422	9.97 683	4	27
34	9.50 298	37	9.52 619	42	0.47 380	9.97 678	4	26
35	9.50 336	37	9.52 661	42	0.47 338	9.97 674	4	25
36	9.50 373	37	9.52 703	41	0.47 296	9.97 670	4	24
37	9.50 411	37	9.52 745	42	0.47 255	9.97 666	4	23
38	9.50 448	37	9.52 787	41	0.47 213	9.97 661	4	22
39	9.50 486	37	9.52 828	41	0.47 171	9.97 657	4	21
40	9.50 523	37	9.52 870	42	0.47 130	9.97 653	4	20
41	9.50 561	37	9.52 912	41	0.47 088	9.97 649	4	19
42	9.50 598	37	9.52 953	41	0.47 046	9.97 644	4	18
43	9.50 635	37	9.52 995	41	0.47 005	9.97 640	4	17
44	9.50 672	37	9.53 036	41	0.46 963	9.97 636	4	16
45	9.50 710	37	9.53 078	41	0.46 922	9.97 632	4	15
46	9.50 747	37	9.53 119	41	0.46 880	9.97 627	4	14
47	9.50 784	37	9.53 161	41	0.46 839	9.97 623	4	13
48	9.50 821	37	9.53 202	41	0.46 797	9.97 619	4	12
49	9.50 858	37	9.53 244	41	0.46 756	9.97 614	4	11
50	9.50 895	37	9.53 285	41	0.46 714	9.97 610	4	10
51	9.50 932	37	9.53 326	41	0.46 673	9.97 606	4	9
52	9.50 969	37	9.53 368	41	0.46 632	9.97 601	4	8
53	9.51 006	37	9.53 409	41	0.46 591	9.97 597	4	7
54	9.51 043	37	9.53 450	41	0.46 549	9.97 593	4	6
55	9.51 080	37	9.53 491	41	0.46 508	9.97 588	4	5
56	9.51 117	36	9.53 533	41	0.46 467	9.97 584	4	4
57	9.51 154	37	9.53 574	41	0.46 426	9.97 580	4	3
58	9.51 190	36	9.53 615	41	0.46 385	9.97 575	4	2
59	9.51 227	37	9.53 656	41	0.46 344	9.97 571	4	1
60	9.51 264	36	9.53 697	41	0.46 303	9.97 567	4	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	43	42	42
6	4.3	4.2	4.2
7	5.0	4.9	4.9
8	5.7	5.6	5.6
9	6.4	6.4	6.3
10	7.1	7.1	7.0
20	14.3	14.1	14.0
30	21.5	21.2	21.0
40	28.6	28.3	28.0
50	35.8	35.4	35.0

	41	41
6	4.1	4.1
7	4.8	4.8
8	5.5	5.4
9	6.2	6.1
10	6.9	6.8
20	13.8	13.6
30	20.7	20.5
40	27.6	27.3
50	34.6	34.1

	39	38	38
6	3.9	3.8	3.8
7	4.5	4.5	4.4
8	5.2	5.1	5.0
9	5.8	5.8	5.7
10	6.5	6.4	6.3
20	13.0	12.8	12.6
30	19.5	19.2	19.0
40	26.0	25.6	25.3
50	32.5	32.1	31.6

	37	37	36
6	3.7	3.7	3.6
7	4.4	4.3	4.2
8	5.0	4.9	4.8
9	5.6	5.5	5.5
10	6.2	6.1	6.1
20	12.5	12.3	12.1
30	18.7	18.5	18.2
40	25.0	24.6	24.3
50	31.2	30.8	30.4

	4	4
6	0.4	0.4
7	0.5	0.4
8	0.6	0.5
9	0.7	0.6
10	0.7	0.6
20	1.5	1.3
30	2.2	2.0
40	3.0	2.6
50	3.7	3.3

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
0	9.51 264	37	9.53 697	41	0.46 303	9.97 567	4	60
1	9.51 301	36	9.53 738	41	0.46 262	9.97 562	4	59
2	9.51 337	36	9.53 779	41	0.46 221	9.97 558	4	58
3	9.51 374	36	9.53 820	41	0.46 180	9.97 554	4	57
4	9.51 410	36	9.53 861	41	0.46 139	9.97 549	4	56
5	9.51 447	36	9.53 902	41	0.46 098	9.97 545	4	55
6	9.51 483	36	9.53 943	41	0.46 057	9.97 541	4	54
7	9.51 520	36	9.53 985	41	0.46 016	9.97 536	4	53
8	9.51 556	36	9.54 024	41	0.45 975	9.97 532	4	52
9	9.51 593	36	9.54 065	41	0.45 934	9.97 527	4	51
10	9.51 629	36	9.54 106	41	0.45 894	9.97 523	4	50
11	9.51 665	36	9.54 147	41	0.45 853	9.97 519	4	49
12	9.51 702	36	9.54 187	40	0.45 812	9.97 514	4	48
13	9.51 738	36	9.54 228	41	0.45 772	9.97 510	4	47
14	9.51 774	36	9.54 269	41	0.45 731	9.97 505	4	46
15	9.51 810	36	9.54 309	40	0.45 690	9.97 501	4	45
16	9.51 847	36	9.54 350	40	0.45 650	9.97 497	4	44
17	9.51 883	36	9.54 390	40	0.45 609	9.97 492	4	43
18	9.51 919	36	9.54 431	40	0.45 569	9.97 488	4	42
19	9.51 955	36	9.54 471	40	0.45 528	9.97 483	4	41
20	9.51 991	36	9.54 512	40	0.45 488	9.97 479	4	40
21	9.52 027	36	9.54 552	40	0.45 447	9.97 475	4	39
22	9.52 063	36	9.54 593	40	0.45 407	9.97 470	4	38
23	9.52 099	36	9.54 633	40	0.45 367	9.97 466	4	37
24	9.52 135	36	9.54 673	40	0.45 326	9.97 461	4	36
25	9.52 170	35	9.54 714	40	0.45 286	9.97 457	4	35
26	9.52 206	36	9.54 754	40	0.45 246	9.97 452	4	34
27	9.52 242	36	9.54 794	40	0.45 205	9.97 448	4	33
28	9.52 278	35	9.54 834	40	0.45 165	9.97 443	4	32
29	9.52 314	36	9.54 874	40	0.45 125	9.97 439	4	31
30	9.52 349	35	9.54 915	40	0.45 085	9.97 434	4	30
31	9.52 385	36	9.54 955	40	0.45 045	9.97 430	4	29
32	9.52 421	36	9.54 995	40	0.45 005	9.97 425	4	28
33	9.52 456	35	9.55 035	40	0.44 965	9.97 421	4	27
34	9.52 492	36	9.55 075	40	0.44 925	9.97 416	4	26
35	9.52 527	35	9.55 115	40	0.44 884	9.97 412	4	25
36	9.52 563	36	9.55 155	40	0.44 845	9.97 407	4	24
37	9.52 598	35	9.55 195	40	0.44 805	9.97 403	4	23
38	9.52 634	36	9.55 235	40	0.44 765	9.97 398	4	22
39	9.52 669	35	9.55 275	40	0.44 725	9.97 394	4	21
40	9.52 704	35	9.55 315	40	0.44 685	9.97 389	4	20
41	9.52 740	36	9.55 355	40	0.44 645	9.97 385	4	19
42	9.52 775	35	9.55 394	39	0.44 605	9.97 380	4	18
43	9.52 810	35	9.55 434	40	0.44 565	9.97 376	4	17
44	9.52 846	36	9.55 474	40	0.44 526	9.97 371	4	16
45	9.52 881	35	9.55 514	40	0.44 486	9.97 367	4	15
46	9.52 916	35	9.55 553	39	0.44 446	9.97 362	4	14
47	9.52 951	35	9.55 593	40	0.44 406	9.97 358	4	13
48	9.52 986	35	9.55 633	40	0.44 367	9.97 353	4	12
49	9.53 021	35	9.55 672	39	0.44 327	9.97 349	4	11
50	9.53 056	35	9.55 712	39	0.44 288	9.97 344	4	10
51	9.53 091	35	9.55 751	39	0.44 248	9.97 340	5	9
52	9.53 126	35	9.55 791	40	0.44 208	9.97 335	4	8
53	9.53 161	35	9.55 831	39	0.44 169	9.97 330	4	7
54	9.53 196	35	9.55 870	39	0.44 129	9.97 326	4	6
55	9.53 231	34	9.55 909	39	0.44 090	9.97 321	5	5
56	9.53 266	35	9.55 949	39	0.44 051	9.97 317	4	4
57	9.53 301	35	9.55 988	39	0.44 011	9.97 312	4	3
58	9.53 335	34	9.56 028	39	0.43 972	9.97 308	5	2
59	9.53 370	35	9.56 067	39	0.43 932	9.97 303	4	1
60	9.53 405	34	9.56 106	39	0.43 893	9.97 298	5	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	41	40	40
6	4.1	4.0	4.0
7	4.8	4.7	4.6
8	5.4	5.4	5.3
9	6.1	6.1	6.0
10	6.8	6.7	6.6
20	13.6	13.5	13.3
30	20.5	20.2	20.0
40	27.3	27.0	26.6
50	34.1	33.7	33.3

	39	39
6	3.9	3.9
7	4.6	4.5
8	5.2	5.2
9	5.9	5.8
10	6.6	6.5
20	13.1	13.0
30	19.7	19.5
40	26.3	26.0
50	32.9	32.5

	37	36	36
6	3.7	3.6	3.6
7	4.3	4.2	4.2
8	4.9	4.8	4.8
9	5.5	5.5	5.4
10	6.1	6.1	6.0
20	12.3	12.1	12.0
30	18.5	18.2	18.0
40	24.6	24.3	24.0
50	30.8	30.4	30.0

	35	35	34
6	3.5	3.5	3.4
7	4.1	4.1	4.0
8	4.7	4.6	4.6
9	5.3	5.2	5.2
10	5.9	5.8	5.7
20	11.8	11.6	11.5
30	17.7	17.5	17.2
40	23.6	23.3	23.0
50	29.6	29.1	28.7

	5	4	4
6	0.5	0.4	0.4
7	0.6	0.5	0.4
8	0.6	0.6	0.5
9	0.7	0.7	0.6
10	0.8	0.7	0.6
20	1.6	1.5	1.3
30	2.5	2.2	2.0
40	3.3	3.0	2.6
50	4.1	3.7	3.3

P. P.

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.	d.	′
0	9.53 405	35	9.56 106	39	0.43 893	9.97 298	7/4	60
1	9.53 440	34	9.56 146	39	0.43 854	9.97 294	7/4	59
2	9.53 474	34	9.56 185	39	0.43 815	9.97 289	7/4	58
3	9.53 509	34	9.56 224	39	0.43 775	9.97 285	7/4	57
4	9.53 544	35	9.56 263	39	0.43 736	9.97 280	5	56
5	9.53 578	34	9.56 303	39	0.43 697	9.97 275	7/4	55
6	9.53 613	34	9.56 342	39	0.43 658	9.97 271	7/4	54
7	9.53 647	34	9.56 381	39	0.43 619	9.97 266	7/4	53
8	9.53 682	34	9.56 420	39	0.43 580	9.97 261	5/4	52
9	9.53 716	34	9.56 459	39	0.43 540	9.97 257	5/4	51
10	9.53 750	34	9.56 498	39	0.43 501	9.97 252	7/4	50
11	9.53 785	34	9.56 537	39	0.43 462	9.97 248	7/4	49
12	9.53 819	34	9.56 576	39	0.43 423	9.97 243	7/4	48
13	9.53 854	34	9.56 615	39	0.43 384	9.97 238	7/4	47
14	9.53 888	34	9.56 654	38	0.43 346	9.97 234	7/4	46
15	9.53 922	34	9.56 693	39	0.43 307	9.97 229	5/4	45
16	9.53 956	34	9.56 732	39	0.43 268	9.97 224	5/4	44
17	9.53 990	34	9.56 771	39	0.43 229	9.97 220	5/4	43
18	9.54 025	34	9.56 810	39	0.43 190	9.97 215	5/4	42
19	9.54 059	34	9.56 848	38	0.43 151	9.97 210	5/4	41
20	9.54 093	34	9.56 887	39	0.43 112	9.97 206	7/4	40
21	9.54 127	34	9.56 926	39	0.43 074	9.97 201	5/4	39
22	9.54 161	34	9.56 965	39	0.43 035	9.97 196	5/4	38
23	9.54 195	34	9.57 003	38	0.42 996	9.97 191	5/4	37
24	9.54 229	34	9.57 042	39	0.42 958	9.97 187	5/4	36
25	9.54 263	33	9.57 081	39	0.42 919	9.97 182	7/4	35
26	9.54 297	34	9.57 119	38	0.42 880	9.97 177	5/4	34
27	9.54 331	34	9.57 158	39	0.42 842	9.97 173	5/4	33
28	9.54 365	34	9.57 196	38	0.42 803	9.97 168	5/4	32
29	9.54 398	33	9.57 235	39	0.42 765	9.97 163	5/4	31
30	9.54 432	34	9.57 274	39	0.42 726	9.97 159	7/4	30
31	9.54 466	34	9.57 312	38	0.42 687	9.97 154	5/4	29
32	9.54 500	33	9.57 350	38	0.42 649	9.97 149	5/4	28
33	9.54 534	34	9.57 389	39	0.42 611	9.97 144	5/4	27
34	9.54 567	33	9.57 427	38	0.42 572	9.97 140	5/4	26
35	9.54 601	33	9.57 466	39	0.42 534	9.97 135	5/4	25
36	9.54 634	34	9.57 504	38	0.42 495	9.97 130	5/4	24
37	9.54 668	33	9.57 542	38	0.42 457	9.97 125	5/4	23
38	9.54 702	33	9.57 581	39	0.42 419	9.97 121	5/4	22
39	9.54 735	33	9.57 619	38	0.42 380	9.97 116	5/4	21
40	9.54 769	33	9.57 657	38	0.42 342	9.97 111	7/4	20
41	9.54 802	33	9.57 696	39	0.42 304	9.97 106	5/4	19
42	9.54 836	33	9.57 734	38	0.42 266	9.97 102	5/4	18
43	9.54 869	33	9.57 772	38	0.42 227	9.97 097	5/4	17
44	9.54 902	33	9.57 810	38	0.42 189	9.97 092	5/4	16
45	9.54 936	33	9.57 848	38	0.42 151	9.97 087	7/4	15
46	9.54 969	33	9.57 886	38	0.42 113	9.97 082	5/4	14
47	9.55 002	33	9.57 925	39	0.42 075	9.97 078	5/4	13
48	9.55 036	33	9.57 963	38	0.42 037	9.97 073	5/4	12
49	9.55 069	33	9.58 001	38	0.41 999	9.97 068	5/4	11
50	9.55 102	33	9.58 039	38	0.41 961	9.97 063	5/4	10
51	9.55 135	33	9.58 077	38	0.41 923	9.97 058	5/4	9
52	9.55 168	33	9.58 115	38	0.41 885	9.97 054	5/4	8
53	9.55 202	33	9.58 153	38	0.41 847	9.97 049	5/4	7
54	9.55 235	33	9.58 190	37	0.41 809	9.97 044	5/4	6
55	9.55 268	33	9.58 228	38	0.41 771	9.97 039	7/4	5
56	9.55 301	33	9.58 266	38	0.41 733	9.97 034	5/4	4
57	9.55 334	33	9.58 304	38	0.41 695	9.97 029	5/4	3
58	9.55 367	33	9.58 342	38	0.41 658	9.97 025	5/4	2
59	9.55 400	33	9.58 380	38	0.41 620	9.97 020	5/4	1
60	9.55 433	33	9.58 417	37	0.41 582	9.97 015	5	0
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	39	39	
6	3.9	3.9	
7	4.6	4.5	
8	5.2	5.2	
9	5.9	5.8	
10	6.6	6.5	
20	13.1	13.0	
30	19.7	19.5	
40	26.3	26.0	
50	32.9	32.5	

	38	38	37
6	3.8	3.8	3.7
7	4.5	4.4	4.4
8	5.1	5.0	5.0
9	5.8	5.7	5.6
10	6.4	6.3	6.2
20	12.8	12.6	12.5
30	19.2	19.0	18.7
40	25.6	25.3	25.0
50	32.1	31.6	31.2

	35	34	34
6	3.5	3.4	3.4
7	4.1	4.0	3.9
8	4.6	4.6	4.5
9	5.2	5.2	5.1
10	5.8	5.7	5.6
20	11.6	11.5	11.3
30	17.5	17.2	17.0
40	23.3	23.0	22.6
50	29.1	28.7	28.3

	33	33	
6	3.3	3.3	
7	3.9	3.8	
8	4.4	4.4	
9	5.0	4.9	
10	5.6	5.5	
20	11.1	11.0	
30	16.7	16.5	
40	22.3	22.0	
50	27.9	27.5	

	5	4
6	0.5	0.4
7	0.6	0.5
8	0.6	0.6
9	0.7	0.7
10	0.8	0.7
20	1.6	1.5
30	2.5	2.2
40	3.3	3.0
50	4.1	3.7

21°

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9.55 433		9.58 417		0.41 582	9.97 015		60
1	9.55 466	33	9.58 455	38	0.41 544	9.97 010	4	59
2	9.55 498	32	9.58 493	37	0.41 507	9.97 005	5	58
3	9.55 531	33	9.58 531	38	0.41 469	9.97 000	5	57
4	9.55 564	33	9.58 568	37	0.41 431	9.96 995	5	56
5	9.55 597	32	9.58 606	37	0.41 394	9.96 991	4	55
6	9.55 630	33	9.58 644	38	0.41 356	9.96 986	5	54
7	9.55 662	32	9.58 681	37	0.41 318	9.96 981	5	53
8	9.55 695	33	9.58 719	37	0.41 281	9.96 976	5	52
9	9.55 728	33	9.58 756	37	0.41 243	9.96 971	4	51
10	9.55 760	32	9.58 794	37	0.41 206	9.96 966	5	50
11	9.55 793	32	9.58 831	37	0.41 168	9.96 961	5	49
12	9.55 826	33	9.58 869	37	0.41 131	9.96 956	5	48
13	9.55 858	32	9.58 906	37	0.41 093	9.96 952	4	47
14	9.55 891	32	9.58 944	37	0.41 056	9.96 947	5	46
15	9.55 923	32	9.58 981	37	0.41 018	9.96 942	5	45
16	9.55 956	33	9.59 019	37	0.40 981	9.96 937	5	44
17	9.55 988	32	9.59 056	37	0.40 944	9.96 932	5	43
18	9.56 020	32	9.59 093	37	0.40 906	9.96 927	5	42
19	9.56 053	33	9.59 131	38	0.40 869	9.96 922	4	41
20	9.56 085	32	9.59 168	37	0.40 832	9.96 917	5	40
21	9.56 118	33	9.59 205	37	0.40 794	9.96 912	5	39
22	9.56 150	32	9.59 242	37	0.40 757	9.96 907	5	38
23	9.56 182	32	9.59 280	38	0.40 720	9.96 902	5	37
24	9.56 214	32	9.59 317	37	0.40 683	9.96 897	5	36
25	9.56 247	33	9.59 354	37	0.40 646	9.96 892	5	35
26	9.56 279	32	9.59 391	37	0.40 608	9.96 887	5	34
27	9.56 311	32	9.59 428	37	0.40 571	9.96 882	5	33
28	9.56 343	32	9.59 465	37	0.40 534	9.96 877	5	32
29	9.56 375	32	9.59 502	37	0.40 497	9.96 873	4	31
30	9.56 407	32	9.59 540	37	0.40 460	9.96 868	5	30
31	9.56 439	32	9.59 577	37	0.40 423	9.96 863	5	29
32	9.56 471	32	9.59 614	37	0.40 386	9.96 858	5	28
33	9.56 503	32	9.59 651	37	0.40 349	9.96 853	5	27
34	9.56 535	32	9.59 688	37	0.40 312	9.96 848	5	26
35	9.56 567	32	9.59 724	36	0.40 275	9.96 843	5	25
36	9.56 599	32	9.59 761	37	0.40 238	9.96 838	5	24
37	9.56 631	32	9.59 798	37	0.40 201	9.96 833	5	23
38	9.56 663	32	9.59 835	37	0.40 164	9.96 828	5	22
39	9.56 695	32	9.59 872	36	0.40 128	9.96 823	5	21
40	9.56 727	32	9.59 909	37	0.40 091	9.96 818	5	20
41	9.56 758	31	9.59 946	37	0.40 054	9.96 813	5	19
42	9.56 790	32	9.59 982	36	0.40 017	9.96 808	5	18
43	9.56 822	32	9.60 019	37	0.39 980	9.96 802	5	17
44	9.56 854	32	9.60 056	36	0.39 944	9.96 797	5	16
45	9.56 885	31	9.60 093	37	0.39 907	9.96 792	5	15
46	9.56 917	32	9.60 129	36	0.39 870	9.96 787	5	14
47	9.56 949	32	9.60 166	37	0.39 833	9.96 782	5	13
48	9.56 980	31	9.60 203	36	0.39 797	9.96 777	5	12
49	9.57 012	32	9.60 239	36	0.39 760	9.96 772	5	11
50	9.57 043	31	9.60 276	37	0.39 724	9.96 767	5	10
51	9.57 075	32	9.60 312	36	0.39 687	9.96 762	5	9
52	9.57 106	31	9.60 349	37	0.39 650	9.96 757	5	8
53	9.57 138	32	9.60 386	36	0.39 614	9.96 752	5	7
54	9.57 169	31	9.60 422	36	0.39 577	9.96 747	5	6
55	9.57 201	32	9.60 459	37	0.39 541	9.96 742	5	5
56	9.57 232	31	9.60 495	36	0.39 504	9.96 737	5	4
57	9.57 263	31	9.60 531	36	0.39 468	9.96 732	5	3
58	9.57 295	32	9.60 568	37	0.39 432	9.96 727	5	2
59	9.57 326	31	9.60 604	36	0.39 395	9.96 721	5	1
60	9.57 357	31	9.60 641	36	0.39 359	9.96 716	5	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	38	37	37
6	3.8	3.7	3.7
7	4.4	4.4	4.3
8	5.0	5.0	4.9
9	5.7	5.6	5.5
10	6.3	6.2	6.1
20	12.6	12.5	12.3
30	19.0	18.7	18.5
40	25.3	25.0	24.6
50	31.6	31.2	30.8

	36	36
6	3.6	3.6
7	4.2	4.2
8	4.8	4.8
9	5.5	5.4
10	6.1	6.0
20	12.1	12.0
30	18.2	18.0
40	24.3	24.0
50	30.4	30.0

	33	32	32
6	3.3	3.2	3.2
7	3.8	3.8	3.7
8	4.4	4.3	4.2
9	4.9	4.9	4.8
10	5.5	5.4	5.3
20	11.0	10.8	10.6
30	16.5	16.2	16.0
40	22.0	21.6	21.3
50	27.5	27.1	26.6

	31	31
6	3.1	3.1
7	3.7	3.6
8	4.2	4.1
9	4.7	4.6
10	5.2	5.1
20	10.5	10.3
30	15.7	15.5
40	21.0	20.6
50	26.2	25.8

	5	5	4
6	0.5	0.5	0.4
7	0.6	0.6	0.5
8	0.7	0.6	0.6
9	0.8	0.7	0.7
10	0.9	0.8	0.7
20	1.8	1.6	1.5
30	2.7	2.5	2.2
40	3.6	3.3	3.0
50	4.6	4.1	3.7

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
0	9.57 357	31	9.60 641	36	0.39 359	9.96 716	5	60
1	9.57 389	31	9.60 677	36	0.39 322	9.96 711	5	59
2	9.57 420	31	9.60 713	36	0.39 286	9.96 706	5	58
3	9.57 451	31	9.60 750	36	0.39 250	9.96 701	5	57
4	9.57 482	31	9.60 786	36	0.39 213	9.96 696	5	56
5	9.57 513	31	9.60 822	36	0.39 177	9.96 691	5	55
6	9.57 544	31	9.60 859	36	0.39 141	9.96 686	5	54
7	9.57 576	31	9.60 895	36	0.39 105	9.96 681	5	53
8	9.57 607	31	9.60 931	36	0.39 069	9.96 675	5	52
9	9.57 638	31	9.60 967	36	0.39 032	9.96 670	5	51
10	9.57 669	31	9.61 003	36	0.38 996	9.96 665	5	50
11	9.57 700	31	9.61 039	36	0.38 960	9.96 660	5	49
12	9.57 731	31	9.61 076	36	0.38 924	9.96 655	5	48
13	9.57 762	31	9.61 112	36	0.38 888	9.96 650	5	47
14	9.57 792	30	9.61 148	36	0.38 852	9.96 644	5	46
15	9.57 823	31	9.61 184	36	0.38 816	9.96 639	5	45
16	9.57 854	31	9.61 220	36	0.38 780	9.96 634	5	44
17	9.57 885	31	9.61 256	36	0.38 744	9.96 629	5	43
18	9.57 916	30	9.61 292	36	0.38 708	9.96 624	5	42
19	9.57 947	31	9.61 328	36	0.38 672	9.96 619	5	41
20	9.57 977	30	9.61 364	36	0.38 636	9.96 613	5	40
21	9.58 008	31	9.61 400	36	0.38 600	9.96 608	5	39
22	9.58 039	30	9.61 436	36	0.38 564	9.96 603	5	38
23	9.58 070	31	9.61 472	36	0.38 528	9.96 598	5	37
24	9.58 100	30	9.61 507	35	0.38 492	9.96 593	5	36
25	9.58 131	30	9.61 543	36	0.38 456	9.96 587	5	35
26	9.58 162	31	7.61 579	36	0.38 420	9.96 582	5	34
27	9.58 192	30	9.61 615	36	0.38 385	9.96 577	5	33
28	9.58 223	30	9.61 651	36	0.38 349	9.96 572	5	32
29	9.58 253	30	9.61 686	35	0.38 313	9.96 567	5	31
30	9.58 284	30	9.61 722	36	0.38 277	9.96 561	5	30
31	9.58 314	30	9.61 758	36	0.38 242	9.96 556	5	29
32	9.58 345	30	9.61 794	36	0.38 206	9.96 551	5	28
33	9.58 375	30	9.61 829	35	0.38 170	9.96 546	5	27
34	9.58 406	30	9.61 865	36	0.38 135	9.96 540	5	26
35	9.58 436	30	9.61 901	36	0.38 099	9.96 535	5	25
36	9.58 466	30	9.61 936	35	0.38 063	9.96 530	5	24
37	9.58 497	30	9.61 972	36	0.38 028	9.96 525	5	23
38	9.58 527	30	9.62 007	35	0.37 992	9.96 519	5	22
39	9.58 557	30	9.62 043	36	0.37 957	9.96 514	5	21
40	9.58 587	30	9.62 078	35	0.37 921	9.96 509	5	20
41	9.58 618	30	9.62 114	36	0.37 886	9.96 503	5	19
42	9.58 648	30	9.62 149	35	0.37 850	9.96 498	5	18
43	9.58 678	30	9.62 185	36	0.37 815	9.96 493	5	17
44	9.58 708	30	9.62 220	35	0.37 779	9.96 488	5	16
45	9.58 738	30	9.62 256	36	0.37 744	9.96 482	5	15
46	9.58 769	30	9.62 291	35	0.37 708	9.96 477	5	14
47	9.58 799	30	9.62 327	36	0.37 673	9.96 472	5	13
48	9.58 829	30	9.62 362	35	0.37 637	9.96 466	5	12
49	9.58 859	30	9.62 397	35	0.37 602	9.96 461	5	11
50	9.58 889	30	9.62 433	36	0.37 567	9.96 456	5	10
51	9.58 919	30	9.62 468	35	0.37 531	9.96 450	5	9
52	9.58 949	30	9.62 503	35	0.37 496	9.96 445	5	8
53	9.58 979	30	9.62 539	36	0.37 461	9.96 440	5	7
54	9.59 009	30	9.62 574	35	0.37 426	9.96 434	5	6
55	9.59 038	29	9.62 609	35	0.37 390	9.96 429	5	5
56	9.59 068	30	9.62 644	35	0.37 355	9.96 424	5	4
57	9.59 098	30	9.62 679	35	0.37 320	9.96 418	5	3
58	9.59 128	29	9.62 715	36	0.37 285	9.96 413	5	2
59	9.59 158	30	9.62 750	35	0.37 250	9.96 408	5	1
60	9.59 188		9.62 785	35	0.37 215	9.96 402	5	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	36	36
6	3.6	3.6
7	4.2	4.2
8	4.8	4.8
9	5.5	5.4
10	6.1	6.0
20	12.1	12.0
30	18.2	18.0
40	24.3	24.0
50	30.4	30.0

	35	35
6	3.5	3.5
7	4.1	4.1
8	4.7	4.6
9	5.3	5.2
10	5.9	5.8
20	11.8	11.6
30	17.7	17.5
40	23.6	23.3
50	29.6	29.1

	31	31
6	3.1	3.1
7	3.7	3.6
8	4.2	4.1
9	4.7	4.6
10	5.2	5.1
20	10.5	10.3
30	15.7	15.5
40	21.0	20.6
50	26.2	25.8

	30	30	29
6	3.0	3.0	2.9
7	3.5	3.5	3.4
8	4.0	4.0	3.9
9	4.6	4.5	4.4
10	5.1	5.0	4.9
20	10.1	10.0	9.8
30	15.2	15.0	14.7
40	20.3	20 0	19.6
50	25.4	25.0	24.6

	5	5
6	0.5	0.5
7	0.6	0.6
8	0.7	0.6
9	0.8	0.7
10	0.9	0.8
20	1.8	1.6
30	2.7	2.5
40	3.6	3.3
50	4.6	4.1

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9.59 188	29	9.62 785	35	0.37 215	9.96 402	5	60
1	9.59 217	29	9.62 820	35	0.37 179	9.96 397	5	59
2	9.59 247	30	9.62 855	35	0.37 144	9.96 392	5	58
3	9.59 277	29	9.62 890	35	0.37 109	9.96 386	6	57
4	9.59 306	29	9.62 925	35	0.37 074	9.96 381	5	56
5	9.59 336	30	9.62 960	35	0.37 039	9.96 375	6	55
6	9.59 366	29	9.62 995	35	0.37 004	9.96 370	5	54
7	9.59 395	29	9.63 030	35	0.36 969	9.96 365	5	53
8	9.59 425	29	9.63 065	35	0.36 934	9.96 359	6	52
9	9.59 454	29	9.63 100	35	0.36 899	9.96 354	5	51
10	9.59 484	29	9.63 135	35	0.36 864	9.96 349	5	50
11	9.59 513	29	9.63 170	35	0.36 829	9.96 343	6	49
12	9.59 543	29	9.63 205	34	0.36 794	9.96 338	5	48
13	9.59 572	29	9.63 240	35	0.36 760	9.96 332	6	47
14	9.59 602	29	9.63 275	35	0.36 725	9.96 327	5	46
15	9.59 631	29	9.63 310	34	0.36 690	9.96 321	6	45
16	9.59 661	29	9.63 344	35	0.36 655	9.96 316	5	44
17	9.59 690	29	9.63 379	35	0.36 620	9.96 311	5	43
18	9.59 719	29	9.63 414	34	0.36 585	9.96 305	6	42
19	9.59 749	29	9.63 449	34	0.36 551	9.96 300	5	41
20	9.59 778	29	9.63 484	35	0.36 516	9.96 294	6	40
21	9.59 807	29	9.63 518	34	0.36 481	9.96 289	5	39
22	9.59 837	29	9.63 553	35	0.36 447	9.96 283	6	38
23	9.59 866	29	9.63 588	34	0.36 412	9.96 278	5	37
24	9.59 895	29	9.63 622	34	0.36 377	9.96 272	6	36
25	9.59 924	29	9.63 657	35	0.36 343	9.96 267	5	35
26	9.59 953	29	9.63 692	34	0.36 308	9.96 261	6	34
27	9.59 982	29	9.63 726	34	0.36 273	9.96 256	5	33
28	9.60 012	29	9.63 761	34	0.36 239	9.96 251	5	32
29	9.60 041	29	9.63 795	34	0.36 204	9.96 245	6	31
30	9.60 070	29	9.63 830	34	0.36 170	9.96 240	5	30
31	9.60 099	29	9.63 864	34	0.36 135	9.96 234	6	29
32	9.60 128	29	9.63 899	34	0.36 101	9.96 229	5	28
33	9.60 157	29	9.63 933	34	0.36 066	9.96 223	6	27
34	9.60 186	29	9.63 968	34	0.36 032	9.96 218	5	26
35	9.60 215	29	9.64 002	34	0.35 997	9.96 212	6	25
36	9.60 244	29	9.64 037	34	0.35 963	9.96 206	6	24
37	9.60 273	29	9.64 071	34	0.35 928	9.96 201	5	23
38	9.60 301	28	9.64 106	34	0.35 894	9.96 195	6	22
39	9.60 330	29	9.64 140	34	0.35 859	9.96 190	5	21
40	9.60 359	29	9.64 174	34	0.35 825	9.96 184	6	20
41	9.60 388	29	9.64 209	34	0.35 791	9.96 179	5	19
42	9.60 417	29	9.64 243	34	0.35 756	9.96 173	6	18
43	9.60 445	28	9.64 277	34	0.35 722	9.96 168	5	17
44	9.60 474	29	9.64 312	34	0.35 688	9.96 162	6	16
45	9.60 503	29	9.64 346	34	0.35 653	9.96 157	5	15
46	9.60 532	29	9.64 380	34	0.35 619	9.96 151	6	14
47	9.60 560	28	9.64 415	34	0.35 585	9.96 146	5	13
48	9.60 589	29	9.64 449	34	0.35 551	9.96 140	6	12
49	9.60 618	29	9.64 483	34	0.35 517	9.96 134	6	11
50	9.60 646	28	9.64 517	34	0.35 482	9.96 129	5	10
51	9.60 675	29	9.64 551	34	0.35 448	9.96 123	6	9
52	9.60 703	28	9.64 585	34	0.35 414	9.96 118	5	8
53	9.60 732	29	9.64 620	34	0.35 380	9.96 112	6	7
54	9.60 760	28	9.64 654	34	0.35 346	9.96 106	6	6
55	9.60 789	29	9.64 688	34	0.35 312	9.96 101	5	5
56	9.60 817	28	9.64 722	34	0.35 278	9.96 095	6	4
57	9.60 846	29	9.64 756	34	0.35 244	9.96 090	6	3
58	9.60 874	28	9.64 790	34	0.35 209	9.96 084	6	2
59	9.60 903	29	9.64 824	34	0.35 175	9.96 078	6	1
60	9.60 931	28	9.64 858	34	0.35 141	9.96 073	5	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	35	35
6	3.5	3.5
7	4.1	4.1
8	4.7	4.6
9	5.3	5.2
10	5.9	5.8
20	11.8	11.6
30	17.7	17.5
40	23.6	23.3
50	29.6	29.1

	34	34
6	3.4	3.4
7	4.0	3.9
8	4.6	4.5
9	5.2	5.1
10	5.7	5.6
20	11.5	11.3
30	17.2	17.0
40	23.0	22.6
50	28.7	28.3

	30
6	3.0
7	3.5
8	4.0
9	4.5
10	5.0
20	10.0
30	15.0
40	20.0
50	25.0

	29	29	28
6	2.9	2.9	2.8
7	3.4	3.4	3.3
8	3.9	3.8	3.8
9	4.4	4.3	4.3
10	4.9	4.8	4.7
20	9.8	9.6	9.5
30	14.7	14.5	14.2
40	19.6	19.3	19.0
50	24.6	24.1	23.7

	6	5	5
6	0.6	0.5	0.5
7	0.7	0.6	0.6
8	0.8	0.7	0.6
9	0.9	0.8	0.7
10	1.0	0.9	0.8
20	2.0	1.8	1.6
30	3.0	2.7	2.5
40	4.0	3.6	3.3
50	5.0	4.6	4.1

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9.60 931	28	9.64 858	34	0.35 141	9.96 073	5	60
1	9.60 959	28	9.64 892	34	0.35 107	9.96 067	6	59
2	9.60 988	28	9.64 926	33	0.35 073	9.96 062	6	58
3	9.61 016	28	9.64 960	34	0.35 040	9.96 056	5	57
4	9.61 044	28	9.64 994	34	0.35 006	9.96 050	5	56
5	9.61 073	28	9.65 028	34	0.34 972	9.96 045	6	55
6	9.61 101	28	9.65 062	34	0.34 938	9.96 039	5	54
7	9.61 129	28	9.65 096	33	0.34 904	9.96 033	6	53
8	9.61 157	28	9.65 129	34	0.34 870	9.96 028	6	52
9	9.61 186	28	9.65 163	34	0.34 836	9.96 022	6	51
10	9.61 214	28	9.65 197	33	0.34 802	9.96 016	5	50
11	9.61 242	28	9.65 231	34	0.34 769	9.96 011	6	49
12	9.61 270	28	9.65 265	34	0.34 735	9.96 005	6	48
13	9.61 298	28	9.65 299	33	0.34 701	9.95 999	6	47
14	9.61 326	28	9.65 332	34	0.34 667	9.95 994	5	46
15	9.61 354	28	9.65 366	34	0.34 633	9.95 988	6	45
16	9.61 382	28	9.65 400	33	0.34 600	9.95 982	6	44
17	9.61 410	28	9.65 433	34	0.34 566	9.95 977	6	43
18	9.61 438	28	9.65 467	34	0.34 532	9.95 971	6	42
19	9.61 466	28	9.65 501	33	0.34 499	9.95 965	5	41
20	9.61 494	28	9.65 535	34	0.34 465	9.95 959	6	40
21	9.61 522	28	9.65 568	33	0.34 431	9.95 954	6	39
22	9.61 550	27	9.65 602	33	0.34 398	9.95 948	6	38
23	9.61 578	28	9.65 635	33	0.34 364	9.95 942	6	37
24	9.61 606	28	9.65 669	34	0.34 331	9.95 937	5	36
25	9.61 634	28	9.65 703	33	0.34 297	9.95 931	6	35
26	9.61 661	27	9.65 736	33	0.34 263	9.95 925	6	34
27	9.61 689	28	9.65 770	33	0.34 230	9.95 919	6	33
28	9.61 717	28	9.65 803	33	0.34 196	9.95 914	5	32
29	9.61 745	28	9.65 837	33	0.34 163	9.95 908	6	31
30	9.61 772	27	9.65 870	33	0.34 129	9.95 902	6	30
31	9.61 800	28	9.65 904	33	0.34 096	9.95 896	6	29
32	9.61 828	27	9.65 937	33	0.34 062	9.95 891	6	28
33	9.61 856	28	9.65 971	33	0.34 029	9.95 885	6	27
34	9.61 883	27	9.66 004	33	0.33 996	9.95 879	6	26
35	9.61 911	27	9.66 037	33	0.33 962	9.95 873	6	25
36	9.61 938	27	9.66 071	33	0.33 929	9.95 867	6	24
37	9.61 966	28	9.66 104	33	0.33 895	9.95 862	6	23
38	9.61 994	28	9.66 137	33	0.33 862	9.95 856	6	22
39	9.62 021	27	9.66 171	33	0.33 829	9.95 850	6	21
40	9.62 049	27	9.66 204	33	0.33 795	9.95 844	6	20
41	9.62 076	27	9.66 237	33	0.33 762	9.95 838	6	19
42	9.62 104	27	9.66 271	33	0.33 729	9.95 833	6	18
43	9.62 131	27	9.66 304	33	0.33 696	9.95 827	6	17
44	9.62 158	27	9.66 337	33	0.33 662	9.95 821	6	16
45	9.62 186	27	9.66 370	33	0.33 629	9.95 815	6	15
46	9.62 213	27	9.66 404	33	0.33 596	9.95 809	6	14
47	9.62 241	27	9.66 437	33	0.33 563	9.95 804	6	13
48	9.62 268	27	9.66 470	33	0.33 529	9.95 798	6	12
49	9.62 295	27	9.66 503	33	0.33 496	9.95 792	6	11
50	9.62 323	27	9.66 536	33	0.33 463	9.95 786	6	10
51	9.62 350	27	9.66 570	33	0.33 430	9.95 780	6	9
52	9.62 377	27	9.66 603	33	0.33 397	9.95 774	6	8
53	9.62 404	27	9.66 636	33	0.33 364	9.95 768	6	7
54	9.62 432	27	9.66 669	33	0.33 331	9.95 763	5	6
55	9.62 459	27	9.66 702	33	0.33 298	9.95 757	6	5
56	9.62 486	27	9.66 735	33	0.33 265	9.95 751	6	4
57	9.62 513	27	9.66 768	33	0.33 232	9.95 745	6	3
58	9.62 540	27	9.66 801	33	0.33 199	9.95 739	6	2
59	9.62 567	27	9.66 834	33	0.33 165	9.95 733	6	1
60	9.62 595	27	9.66 867	33	0.33 132	9.95 727	6	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	34	33	33
6	3.4	3.3	3.3
7	3.9	3.9	3.8
8	4.5	4.4	4.4
9	5.1	5.0	4.9
10	5.6	5.6	5.5
20	11.3	11.1	11.0
30	17.0	16.7	16.5
40	22.6	22.3	22.0
50	28.3	27.9	27.5

	28	28
6	2.8	2.8
7	3.3	3.2
8	3.8	3.7
9	4.3	4.2
10	4.7	4.6
20	9.5	9.3
30	14.2	14.0
40	19.0	18.6
50	23.7	23.3

	27	27
6	2.7	2.7
7	3.2	3.1
8	3.6	3.6
9	4.1	4.0
10	4.6	4.5
20	9.1	9.0
30	13.7	13.5
40	18.3	18.0
50	22.9	22.5

	6	5
6	0.6	0.5
7	0.7	0.6
8	0.8	0.7
9	0.9	0.8
10	1.0	0.9
20	2.0	1.8
30	3.0	2.7
40	4.0	3.6
50	5.0	4.6

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9·62 595	27	9·66 867	33	0·33 132	9·95 727	6	60
1	9·62 622	27	9·66 900	33	0·33 100	9·95 721	6	59
2	9·62 649	27	9·66 933	33	0·33 067	9·95 716	6	58
3	9·62 676	27	9·66 966	33	0·33 034	9·95 710	6	57
4	9·62 703	27	9·66 999	33	0·33 001	9·95 704	6	56
5	9·62 730	27	9·67 032	33	0·32 968	9·95 698	6	55
6	9·62 757	27	9·67 065	33	0·32 935	9·95 692	6	54
7	9·62 784	27	9·67 097	32	0·32 902	9·95 686	6	53
8	9·62 811	27	9·67 130	33	0·32 869	9·95 680	6	52
9	9·62 838	27	9·67 163	33	0·32 836	9·95 674	6	51
10	9·62 864	26	9·67 196	33	0·32 803	9·95 668	6	50
11	9·62 891	27	9·67 229	33	0·32 771	9·95 662	6	49
12	9·62 918	27	9·67 262	33	0·32 738	9·95 656	6	48
13	9·62 945	27	9·67 294	32	0·32 705	9·95 650	6	47
14	9·62 972	26	9·67 327	33	0·32 672	9·95 644	6	46
15	9·62 999	27	9·67 360	32	0·32 640	9·95 638	6	45
16	9·63 025	26	9·67 393	33	0·32 607	9·95 632	6	44
17	9·63 052	27	9·67 425	32	0·32 574	9·95 627	6	43
18	9·63 079	27	9·67 458	33	0·32 541	9·95 621	6	42
19	9·63 106	27	9·67 491	33	0·32 509	9·95 615	6	41
20	9·63 132	26	9·67 525	32	0·32 476	9·95 609	6	40
21	9·63 159	27	9·67 556	33	0·32 443	9·95 603	6	39
22	9·63 186	27	9·67 589	32	0·32 411	9·95 597	6	38
23	9·63 212	26	9·67 621	32	0·32 378	9·95 591	6	37
24	9·63 239	27	9·67 654	33	0·32 345	9·95 585	6	36
25	9·63 266	27	9·67 687	33	0·32 313	9·95 579	6	35
26	9·63 292	26	9·67 719	32	0·32 280	9·95 573	6	34
27	9·63 319	27	9·67 752	33	0·32 248	9·95 567	6	33
28	9·63 345	26	9·67 784	32	0·32 215	9·95 561	6	32
29	9·63 372	27	9·67 817	33	0·32 183	9·95 555	6	31
30	9·63 398	26	9·67 849	32	0·32 150	9·95 549	6	30
31	9·63 425	27	9·67 882	33	0·32 118	9·95 543	6	29
32	9·63 451	26	9·67 914	32	0·32 085	9·95 537	6	28
33	9·63 478	27	9·67 947	33	0·32 053	9·95 530	7	27
34	9·63 504	26	9·67 979	32	0·32 020	9·95 524	6	26
35	9·63 530	26	9·68 012	33	0·31 988	9·95 518	6	25
36	9·63 557	27	9·68 044	32	0·31 955	9·95 512	6	24
37	9·63 583	26	9·68 077	33	0·31 923	9·95 506	6	23
38	9·63 609	26	9·68 109	32	0·31 891	9·95 500	6	22
39	9·63 636	27	9·68 141	32	0·31 858	9·95 494	6	21
40	9·63 662	26	9·68 174	33	0·31 826	9·95 488	6	20
41	9·63 688	26	9·68 206	32	0·31 793	9·95 482	6	19
42	9·63 715	27	9·68 238	32	0·31 761	9·95 476	6	18
43	9·63 741	26	9·68 271	33	0·31 729	9·95 470	6	17
44	9·63 767	26	9·68 303	32	0·31 696	9·95 464	6	16
45	9·63 793	26	9·68 335	32	0·31 664	9·95 458	6	15
46	9·63 819	26	9·68 368	33	0·31 632	9·95 452	6	14
47	9·63 846	26	9·68 400	32	0·31 600	9·95 445	6	13
48	9·63 872	26	9·68 432	32	0·31 567	9·95 439	6	12
49	9·63 898	26	9·68 464	32	0·31 535	9·95 433	6	11
50	9·63 924	26	9·68 497	32	0·31 503	9·95 427	6	10
51	9·63 950	26	9·68 529	32	0·31 471	9·95 421	6	9
52	9·63 976	26	9·68 561	32	0·31 439	9·95 415	6	8
53	9·64 002	26	9·68 593	32	0·31 406	9·95 409	6	7
54	9·64 028	26	9·68 625	32	0·31 374	9·95 403	6	6
55	9·64 054	26	9·68 657	32	0·31 342	9·95 397	6	5
56	9·64 080	26	9·68 690	32	0·31 310	9·95 390	6	4
57	9·64 106	26	9·68 722	32	0·31 278	9·95 384	6	3
58	9·64 132	26	9·68 754	32	0·31 246	9·95 378	6	2
59	9·64 158	26	9·68 786	32	0·31 214	9·95 372	6	1
60	9·64 184	25	9·68 818	32	0·31 182	9·95 366	6	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	33	32	32
6	3·3	3·2	3·2
7	3·8	3·8	3·7
8	4·4	4·3	4·2
9	4·9	4·9	4·8
10	5·5	5·4	5·3
20	11·0	10·8	10·6
30	16·5	16·2	16·0
40	22·0	21·6	21·3
50	27·5	27·1	26·6

	27
6	2·7
7	3·1
8	3·6
9	4·0
10	4·5
20	9·0
30	13·5
40	18·0
50	22·5

	26	26	25
6	2·6	2·6	2·5
7	3·1	3·0	3·0
8	3·5	3·4	3·4
9	4·0	3·9	3·8
10	4·4	4·3	4·2
20	8·8	8·6	8·5
30	13·2	13·0	12·7
40	17·6	17·3	17·0
50	22·1	21·6	21·2

	6	6	5
6	0·6	0·6	0·5
7	0·7	0·7	0·6
8	0·8	0·8	0·7
9	1·0	0·9	0·8
10	1·1	1·0	0·9
20	2·1	2·0	1·8
30	3·2	3·0	2·7
40	4·3	4·0	3·6
50	5·4	5·0	4·6

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9.64 184		9.68 818		0.31 182	9.95 366		60
1	9.64 210	26	9.68 850	32	0.31 150	9.95 360	6	59
2	9.64 236	26	9.68 882	32	0.31 117	9.95 353	6	58
3	9.64 262	26	9.68 914	32	0.31 085	9.95 347	6	57
4	9.64 287	25	9.68 946	32	0.31 053	9.95 341	6	56
5	9.64 313	26	9.68 978	32	0.31 021	9.95 335	6	55
6	9.64 339	26	9.69 010	32	0.30 989	9.95 329	6	54
7	9.64 365	25	9.69 042	32	0.30 957	9.95 323	6	53
8	9.64 391	26	9.69 074	31	0.30 926	9.95 316	6	52
9	9.64 416	25	9.69 106	32	0.30 894	9.95 310	6	51
10	9.64 442	26	9.69 138	32	0.30 862	9.95 304	6	50
11	9.64 468	25	9.69 170	32	0.30 830	9.95 298	6	49
12	9.64 493	26	9.69 202	32	0.30 798	9.95 292	6	48
13	9.64 519	25	9.69 234	32	0.30 766	9.95 285	6	47
14	9.64 545	25	9.69 265	31	0.30 734	9.95 279	6	46
15	9.64 570	25	9.69 297	32	0.30 702	9.95 273	6	45
16	9.64 596	26	9.69 329	32	0.30 670	9.95 267	6	44
17	9.64 622	25	9.69 361	31	0.30 639	9.95 260	6	43
18	9.64 647	25	9.69 393	32	0.30 607	9.95 254	6	42
19	9.64 673	25	9.69 425	32	0.30 575	9.95 248	6	41
20	9.64 698	25	9.69 456	31	0.30 543	9.95 242	6	40
21	9.64 724	25	9.69 488	32	0.30 511	9.95 235	6	39
22	9.64 749	25	9.69 520	31	0.30 480	9.95 229	6	38
23	9.64 775	25	9.69 552	32	0.30 448	9.95 223	6	37
24	9.64 800	25	9.69 583	31	0.30 416	9.95 217	6	36
25	9.64 826	25	9.69 615	32	0.30 384	9.95 210	6	35
26	9.64 851	25	9.69 647	32	0.30 353	9.95 204	6	34
27	9.64 876	25	9.69 678	31	0.30 321	9.95 198	6	33
28	9.64 902	25	9.69 710	32	0.30 289	9.95 191	6	32
29	9.64 927	25	9.69 742	31	0.30 258	9.95 185	6	31
30	9.64 952	25	9.69 773	31	0.30 226	9.95 179	6	30
31	9.64 978	25	9.69 805	32	0.30 194	9.95 173	6	29
32	9.65 003	25	9.69 837	31	0.30 163	9.95 166	6	28
33	9.65 028	25	9.69 868	31	0.30 131	9.95 160	6	27
34	9.65 054	25	9.69 900	32	0.30 100	9.95 154	6	26
35	9.65 079	25	9.69 931	31	0.30 068	9.95 147	6	25
36	9.65 104	25	9.69 963	31	0.30 037	9.95 141	6	24
37	9.65 129	25	9.69 994	31	0.30 005	9.95 135	6	23
38	9.65 155	25	9.70 026	32	0.29 973	9.95 128	6	22
39	9.65 180	25	9.70 058	31	0.29 942	9.95 122	6	21
40	9.65 205	25	9.70 089	31	0.29 910	9.95 116	6	20
41	9.65 230	25	9.70 121	31	0.29 879	9.95 109	6	19
42	9.65 255	25	9.70 152	31	0.29 847	9.95 103	6	18
43	9.65 280	25	9.70 183	31	0.29 816	9.95 097	6	17
44	9.65 305	25	9.70 215	31	0.29 785	9.95 090	6	16
45	9.65 331	25	9.70 246	31	0.29 753	9.95 084	6	15
46	9.65 356	25	9.70 278	31	0.29 722	9.95 078	6	14
47	9.65 381	25	9.70 309	31	0.29 690	9.95 071	6	13
48	9.65 406	25	9.70 341	31	0.29 659	9.95 065	6	12
49	9.65 431	25	9.70 372	31	0.29 628	9.95 058	6	11
50	9.65 456	25	9.70 403	31	0.29 596	9.95 052	6	10
51	9.65 481	25	9.70 435	31	0.29 565	9.95 046	6	9
52	9.65 506	24	9.70 466	31	0.29 533	9.95 039	6	8
53	9.65 530	25	9.70 497	31	0.29 502	9.95 033	6	7
54	9.65 555	25	9.70 529	31	0.29 471	9.95 026	6	6
55	9.65 580	25	9.70 560	31	0.29 439	9.95 020	6	5
56	9.65 605	24	9.70 591	31	0.29 408	9.95 014	6	4
57	9.65 630	25	9.70 623	31	0.29 377	9.95 007	6	3
58	9.65 655	25	9.70 654	31	0.29 346	9.95 001	6	2
59	9.65 680	24	9.70 685	31	0.29 314	9.94 994	6	1
60	9.65 704		9.70 716		0.29 283	9.94 988	6	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	32	32
6	3.2	3.2
7	3.8	3.7
8	4.3	4.2
9	4.9	4.8
10	5.4	5.3
20	10.8	10.6
30	16.2	16.0
40	21.6	21.3
50	27.1	26.6

	31	31
6	3.1	3.1
7	3.7	3.6
8	4.2	4.1
9	4.7	4.6
10	5.2	5.1
20	10.5	10.3
30	15.7	15.5
40	21.0	20.6
50	26.2	25.8

	26	25	25
6	2.6	2.5	2.5
7	3.0	3.0	2.9
8	3.4	3.4	3.3
9	3.9	3.8	3.7
10	4.3	4.2	4.1
20	8.6	8.5	8.3
30	13.0	12.7	12.5
40	17.3	17.0	16.6
50	21.6	21.2	20.8

	24	6	6
6	2.4	0.6	0.6
7	2.8	0.7	0.7
8	3.2	0.8	0.8
9	3.7	1.0	0.9
10	4.1	1.1	1.0
20	8.1	2.1	2.0
30	12.2	3.2	3.0
40	16.3	4.3	4.0
50	20.4	5.4	5.0

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot	Log. Cos.	d.		P. P.
0	9.65 704	25	9.70 716	31	0.29 283	9.94 988	6	60	
1	9.65 729	24	9.70 748	31	0.29 252	9.94 981	6	59	
2	9.65 754	25	9.70 779	31	0.29 221	9.94 975	6	58	
3	9.65 779	24	9.70 810	31	0.29 190	9.94 969	6	57	
4	9.65 803	24	9.70 841	31	0.29 158	9.94 962	6	56	
5	9.65 828	25	9.70 872	31	0.29 127	9.94 956	6	55	
6	9.65 853	24	9.70 903	31	0.29 096	9.94 949	6	54	
7	9.65 878	25	9.70 935	31	0.29 065	9.94 943	6	53	31 31 30
8	9.65 902	24	9.70 966	31	0.29 034	9.94 936	6	52	6 3.1 3.1 3.0
9	9.65 927	24	9.70 997	31	0.29 003	9.94 930	6	51	7 3.7 3.6 3.5
10	9.65 951	24	9.71 028	31	0.28 972	9.94 923	6	50	8 4.2 4.1 4.0
11	9.65 976	25	9.71 059	31	0.28 940	9.94 917	6	49	9 4.7 4.6 4.6
12	9.66 001	24	9.71 090	31	0.28 909	9.94 910	6	48	10 5.2 5.1 5.1
13	9.66 025	24	9.71 121	31	0.28 878	9.94 904	6	47	20 10.5 10.3 10.2
14	9.66 050	24	9.71 152	31	0.28 847	9.94 897	6	46	30 15.7 15.5 15.2
15	9.66 074	24	9.71 183	31	0.28 816	9.94 891	6	45	40 21.0 20.6 20.3
16	9.66 099	24	9.71 214	31	0.28 785	9.94 884	6	44	50 26.2 25.8 25.4
17	9.66 123	24	9.71 245	31	0.28 754	9.94 878	6	43	
18	9.66 148	24	9.71 276	31	0.28 723	9.94 871	6	42	
19	9.66 172	24	9.71 307	31	0.28 692	9.94 865	6	41	
20	9.66 197	24	9.71 338	31	0.28 661	9.94 858	6	40	25
21	9.66 221	24	9.71 369	31	0.28 630	9.94 852	6	39	6 2.5
22	9.66 246	24	9.71 400	31	0.28 599	9.94 845	6	38	7 2.9
23	9.66 270	24	9.71 431	31	0.28 568	9.94 839	6	37	8 3.3
24	9.66 294	24	9.71 462		0.28 537	9.94 832	6	36	9 3.7
25	9.66 319	24	9.71 493	31	0.28 506	9.94 825	7	35	10 4.1
26	9.66 343	24	9.71 524	30	0.28 476	9.94 819	6	34	20 8.3
27	9.66 367	24	9.71 555	31	0.28 445	9.94 812	6	33	30 12.5
28	9.66 392	24	9.71 586	31	0.28 414	9.94 806	6	32	40 16.6
29	9.66 416	24	9.71 617	31	0.28 383	9.94 799	6	31	50 20.8
30	9.66 440	24	9.71 647	30	0.28 352	9.94 793	6	30	
31	9.66 465	24	9.71 678	31	0.28 321	9.94 786	7	29	
32	9.66 489	24	9.71 709	31	0.28 290	9.94 779	6	28	
33	9.66 513	24	9.71 740	30	0.28 260	9.94 773	6	27	24 24 23
34	9.66 537	24	9.71 771	31	0.28 229	9.94 766	6	26	6 2.4 2.4 2.3
35	9.66 561	24	9.71 801	30	0.28 198	9.94 760	6	25	7 2.8 2.8 2.7
36	9.66 586	24	9.71 832	31	0.28 167	9.94 753	7	24	8 3.2 3.2 3.1
37	9.66 610	24	9.71 863	31	0.28 136	9.94 746	6	23	9 3.7 3.6 3.5
38	9.66 634	24	9.71 894	30	0.28 106	9.94 740	6	22	10 4.1 4.0 3.9
39	9.66 658	24	9.71 925	31	0.28 075	9.94 733	7	21	20 8.1 8.0 7.8
40	9.66 682	24	9.71 955	30	0.28 044	9.94 727	6	20	30 12.2 12.0 11.7
41	9.66 706	24	9.71 986	30	0.28 014	9.94 720	7	19	40 16.3 16.0 15.6
42	9.66 730	24	9.72 017	31	0.27 983	9.94 713	6	18	50 20.4 20.0 19.6
43	9.66 754	24	9.72 047	30	0.27 952	9.94 707	6	17	
44	9.66 778	24	9.72 078	31	0.27 921	9.94 700	7	16	
45	9.66 802	24	9.72 109	30	0.27 891	9.94 693	6	15	7 6 6
46	9.66 826	24	9.72 139	30	0.27 860	9.94 687	6	14	6 0.7 0.6 0.6
47	9.66 850	24	9.72 170	30	0.27 830	9.94 680	7	13	7 0.8 0.7 0.7
48	9.66 874	24	9.72 201	31	0.27 799	9.94 674	6	12	8 0.9 0.8 0.8
49	9.66 898	24	9.72 231	30	0.27 768	9.94 667	7	11	9 1.0 1.0 0.9
50	9.66 922	24	9.72 262	30	0.27 738	9.94 660	6	10	10 1.1 1.1 1.0
51	9.66 946	24	9.72 292	30	0.27 707	9.94 654	7	9	20 2.3 2.2 2.0
52	9.66 970	24	9.72 323	31	0.27 677	9.94 647	7	8	30 3.5 3.3 3.0
53	9.66 994	24	9.72 354	30	0.27 646	9.94 640	7	7	40 4.6 4.4 4.0
54	9.67 018	24	9.72 384	30	0.27 615	9.94 633	7	6	50 5.8 5.4 5.0
55	9.67 042	24	9.72 415	30	0.27 585	9.94 627	6	5	
56	9.67 066	24	9.72 445	30	0.27 554	9.94 620	7	4	
57	9.67 089	23	9.72 476	30	0.27 524	9.94 613	7	3	
58	9.67 113	24	9.72 506	30	0.27 493	9.94 607	6	2	
59	9.67 137	23	9.72 537	30	0.27 463	9.94 600	7	1	
60	9.67 161	24	9.72 567	30	0.27 432	9.94 593	6	0	
	Log. Cos.	d.	Log. Cot	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9.67 161	23	9.72 567	30	0.27 433	9.94 593	6	60
1	9.67 184	24	9.72 598	30	0.27 402	9.94 587	7	59
2	9.67 208	23	9.72 628	30	0.27 371	9.94 580	6	58
3	9.67 232	24	9.72 659	30	0.27 341	9.94 573	7	57
4	9.67 256		9.72 689		0.27 311	9.94 566		56
5	9.67 279	23	9.72 719	30	0.27 280	9.94 560	6	55
6	9.67 303	23	9.72 750	30	0.27 250	9.94 553	7	54
7	9.67 327	24	9.72 780	30	0.27 219	9.94 546	6	53
8	9.67 350	23	9.72 811	30	0.27 189	9.94 539	7	52
9	9.67 374	23	9.72 841		0.27 159	9.94 533	6	51
10	9.67 397	23	9.72 871	30	0.27 128	9.94 526	7	50
11	9.67 421	24	9.72 902	30	0.27 098	9.94 519	6	49
12	9.67 445	23	9.72 932	30	0.27 067	9.94 512	7	48
13	9.67 468	23	9.72 962	30	0.27 037	9.94 506	6	47
14	9.67 492	23	9.72 993		0.27 007	9.94 499	7	46
15	9.67 515	23	9.73 023	30	0.26 976	9.94 492	6	45
16	9.67 539	23	9.73 053	30	0.26 946	9.94 485	7	44
17	9.67 562	23	9.73 084	30	0.26 916	9.94 478	7	43
18	9.67 586	23	9.73 114	30	0.26 886	9.94 472	6	42
19	9.67 609	23	9.73 144	30	0.26 855	9.94 465	7	41
20	9.67 633	23	9.73 174	30	0.26 825	9.94 458	7	40
21	9.67 656	23	9.73 205	30	0.26 795	9.94 451	6	39
22	9.67 679	23	9.73 235	30	0.26 765	9.94 444	7	38
23	9.67 703	23	9.73 265	30	0.26 734	9.94 437	7	37
24	9.67 726	23	9.73 295	30	0.26 704	9.94 431	6	36
25	9.67 750	23	9.73 325	30	0.26 674	9.94 424	7	35
26	9.67 773	23	9.73 356	30	0.26 644	9.94 417	7	34
27	9.67 796	23	9.73 386	30	0.26 614	9.94 410	7	33
28	9.67 819	23	9.73 416	30	0.26 584	9.94 403	7	32
29	9.67 843	23	9.73 446	30	0.26 553	9.94 396	7	31
30	9.67 866	23	9.73 476	30	0.26 523	9.94 390	6	30
31	9.67 889	23	9.73 506	30	0.26 493	9.94 383	7	29
32	9.67 913	23	9.73 536	30	0.26 463	9.94 376	7	28
33	9.67 936	23	9.73 567	30	0.26 433	9.94 369	7	27
34	9.67 959	23	9.73 597	30	0.26 403	9.94 362	7	26
35	9.67 982	23	9.73 627	30	0.26 373	9.94 355	7	25
36	9.68 005	23	9.73 657	30	0.26 343	9.94 348	7	24
37	9.68 029	23	9.73 687	30	0.26 313	9.94 341	7	23
38	9.68 052	23	9.73 717	30	0.26 283	9.94 335	6	22
39	9.68 075	23	9.73 747	30	0.26 253	9.94 328	7	21
40	9.68 098	23	9.73 777	30	0.26 223	9.94 321	7	20
41	9.68 121	23	9.73 807	30	0.26 193	9.94 314	7	19
42	9.68 144	23	9.73 837	30	0.26 163	9.94 307	7	18
43	9.68 167	23	9.73 867	30	0.26 133	9.94 300	6	17
44	9.68 190	23	9.73 897	30	0.26 103	9.94 293	7	16
45	9.68 213	23	9.73 927	30	0.26 073	9.94 286	7	15
46	9.68 236	23	9.73 957	30	0.26 043	9.94 279	7	14
47	9.68 259	23	9.73 987	30	0.26 013	9.94 272	7	13
48	9.68 282	23	9.74 017	30	0.25 983	9.94 265	7	12
49	9.68 305	23	9.74 047	29	0.25 953	9.94 258	7	11
50	9.68 328	23	9.74 076	30	0.25 923	9.94 251	6	10
51	9.68 351	23	9.74 106	30	0.25 893	9.94 245	7	9
52	9.68 374	23	9.74 136	30	0.25 863	9.94 238	7	8
53	9.68 397	23	9.74 166	30	0.25 833	9.94 231	7	7
54	9.68 420	23	9.74 196	29	0.25 804	9.94 224	7	6
55	9.68 443	23	9.74 226	30	0.25 774	9.94 217	7	5
56	9.68 466	23	9.74 256	30	0.25 744	9.94 210	7	4
57	9.68 488	22	9.74 286	30	0.25 714	9.94 203	7	3
58	9.68 511	23	9.74 315	29	0.25 684	9.94 196	7	2
59	9.68 534	23	9.74 345	30	0.25 654	9.94 189	7	1
60	9.68 557	22	9.74 375	29	0.25 625	9.94 182	7	0
′	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	30	20	29
6	3.0	2.0	2.9
7	3.5	3.5	3.4
8	4.0	4.0	3.9
9	4.6	4.5	4.4
10	5.1	5.0	4.9
20	10.1	10.0	9.8
30	15.2	15.0	14.7
40	20.3	20.0	19.6
50	25.4	25.0	24.6

	24
6	2.4
7	2.8
8	3.2
9	3.6
10	4.0
20	8.0
30	12.0
40	16.0
50	20.0

	23	23	22
6	2.3	2.3	2.2
7	2.7	2.7	2.6
8	3.1	3.0	3.0
9	3.5	3.4	3.4
10	3.9	3.8	3.7
20	7.8	7.6	7.5
30	11.7	11.5	11.2
40	15.6	15.3	15.0
50	19.6	19.1	18.7

	7	6
6	0.7	0.6
7	0.8	0.7
8	0.9	0.8
9	1.0	1.0
10	1.1	1.1
20	2.3	2.1
30	3.5	3.2
40	4.6	4.3
50	5.8	5.4

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
0	9·68 557		9·74 370		0·25 625	9·94 182		60
1	9·68 580	23	9·74 405	30	0·25 595	9·94 175	7	59
2	9·68 602	22	9·74 435	30	0·25 565	9·94 168	7	58
3	9·68 625	23	9·74 464	29	0·25 535	9·94 161	7	57
4	9·68 648	22	9·74 494	30	0·25 505	9·94 154	7	56
5	9·68 671	23	9·74 524	30	0·25 476	9·94 147	7	55
6	9·68 693	22	9·74 554	29	0·25 446	9·94 140	7	54
7	9·68 716	23	9·74 583	29	0·25 416	9·94 133	7	53
8	9·68 739	22	9·74 613	30	0·25 387	9·94 126	7	52
9	9·68 761	22	9·74 643	29	0·25 357	9·94 118	7	51
10	9·68 784	23	9·74 672	29	0·25 327	9·94 111	7	50
11	9·68 807	22	9·74 702	30	0·25 297	9·94 104	7	49
12	9·68 829	22	9·74 732	29	0·25 268	9·94 097	7	48
13	9·68 852	23	9·74 761	29	0·25 238	9·94 090	7	47
14	9·68 874	22	9·74 791	30	0·25 208	9·94 083	7	46
15	9·68 897	23	9·74 821	29	0·25 179	9·94 076	7	45
16	9·68 920	23	9·74 850	29	0·25 149	9·94 069	7	44
17	9·68 942	22	9·74 880	30	0·25 120	9·94 062	7	43
18	9·68 965	23	9·74 909	29	0·25 090	9·94 055	7	42
19	9·68 987	22	9·74 939	30	0·25 060	9·94 048	7	41
20	9·69 010	23	9·74 969	29	0·25 031	9·94 041	7	40
21	9·69 032	22	9·74 998	29	0·25 001	9·94 034	7	39
22	9·69 055	23	9·75 028	30	0·24 972	9·94 026	7	38
23	9·69 077	22	9·75 057	29	0·24 942	9·94 019	7	37
24	9·69 099	22	9·75 087	29	0·24 913	9·94 012	7	36
25	9·69 122	23	9·75 116	29	0·24 883	9·94 005	7	35
26	9·69 144	22	9·75 146	29	0·24 854	9·93 998	7	34
27	9·69 167	23	9·75 175	29	0·24 824	9·93 991	7	33
28	9·69 189	22	9·75 205	30	0·24 795	9·93 984	7	32
29	9·69 211	22	9·75 234	29	0·24 765	9·93 977	7	31
30	9·69 234	23	9·75 264	29	0·24 736	9·93 969	7	30
31	9·69 256	22	9·75 293	30	0·24 706	9·93 962	7	29
32	9·69 278	22	9·75 323	29	0·24 677	9·93 955	7	28
33	9·69 301	23	9·75 352	29	0·24 647	9·93 948	7	27
34	9·69 323	22	9·75 382	30	0·24 618	9·93 941	7	26
35	9·69 345	22	9·75 411	29	0·24 588	9·93 934	7	25
36	9·69 367	22	9·75 441	30	0·24 559	9·93 926	7	24
37	9·69 390	23	9·75 470	29	0·24 529	9·93 919	7	23
38	9·69 412	22	9·75 499	29	0·24 500	9·93 912	7	22
39	9·69 434	22	9·75 529	30	0·24 471	9·93 905	7	21
40	9·69 456	22	9·75 558	29	0·24 441	9·93 898	7	20
41	9·69 478	22	9·75 588	29	0·24 412	9·93 891	7	19
42	9·69 500	22	9·75 617	29	0·24 383	9·93 883	7	18
43	9·69 523	23	9·75 646	29	0·24 353	9·93 876	7	17
44	9·69 545	22	9·75 676	30	0·24 324	9·93 869	7	16
45	9·69 567	22	9·75 705	29	0·24 295	9·93 862	7	15
46	9·69 589	22	9·75 734	29	0·24 265	9·93 854	7	14
47	9·69 611	22	9·75 764	30	0·24 236	9·93 847	7	13
48	9·69 633	22	9·75 793	29	0·24 207	9·93 840	7	12
49	9·69 655	22	9·75 822	29	0·24 177	9·93 833	7	11
50	9·69 677	22	9·75 851	29	0·24 148	9·93 826	7	10
51	9·69 699	22	9·75 881	29	0·24 119	9·93 818	7	9
52	9·69 721	22	9·75 910	29	0·24 090	9·93 811	7	8
53	9·69 743	22	9·75 939	29	0·24 060	9·93 804	7	7
54	9·69 765	22	9·75 968	29	0·24 031	9·93 796	7	6
55	9·69 787	22	9·75 998	30	0·24 002	9·93 789	7	5
56	9·69 809	22	9·76 027	29	0·23 973	9·93 782	7	4
57	9·69 831	22	9·76 056	29	0·23 943	9·93 775	7	3
58	9·69 853	21	9·76 085	29	0·23 914	9·93 767	7	2
59	9·69 875	22	9·76 115	29	0·23 885	9·93 760	7	1
60	9·69 897	22	9·76 144	29	0·23 856	9·93 753	7	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	30	29	29
6	3.0	2.9	2.9
7	3.5	3.4	3.4
8	4.0	3.9	3.8
9	4.5	4.4	4.3
10	5.0	4.9	4.8
20	10.0	9.8	9.6
30	15.0	14.7	14.5
40	20.0	19.6	19.3
50	25.0	24.6	24.1

	23
6	2.3
7	2.7
8	3.0
9	3.4
10	3.8
20	7.6
30	11.5
40	15.3
50	19.1

	22	22	21
6	2.2	2.2	2.1
7	2.6	2.5	2.5
8	3.0	2.9	2.8
9	3.4	3.3	3.2
10	3.7	3.6	3.6
20	7.5	7.3	7.1
30	11.2	11.0	10.7
40	15.0	14.6	14.3
50	18.7	18.3	17.9

	7	7
6	0.7	0.7
7	0.9	0.8
8	1.0	0.9
9	1.1	1.0
10	1.2	1.1
20	2.5	2.3
30	3.7	3.5
40	5.0	4.6
50	6.2	5.8

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9.69 897	22	9.76 144	29	0.23 856	9.93 753	7 7	60	
1	9.69 919	21	9.76 173	29	0.23 827	9.93 746	7 7	59	
2	9.69 940	22	9.76 202	29	0.23 797	9.93 738	7 7	58	
3	9.69 962	22	9.76 231	29	0.23 768	9.93 731	7 7	57	
4	9.69 984	22	9.76 260	29	0.23 739	9.93 724	7 7	56	
5	9.70 006	21	9.76 289	29	0.23 710	9.93 716	7 7	55	
6	9.70 028	22	9.76 319	28	0.23 681	9.93 709	7 7	54	
7	9.70 050	22	9.76 348	29	0.23 652	9.93 702	7 7	53	
8	9.70 071	21	9.76 377	29	0.23 623	9.93 694	7 7	52	
9	9.70 093	22	9.76 406	29	0.23 594	9.93 687	7 7	51	29 29 28
10	9.70 115	21	9.76 435	29	0.23 565	9.93 680	7 7	50	6 2.9 2.9 2.8
11	9.70 137	22	9.76 464	29	0.23 535	9.93 672	7 7	49	7 3.4 3.4 3.3
12	9.70 158	21	9.76 493	29	0.23 506	9.93 665	7 7	48	8 3.9 3.8 3.8
13	9.70 180	22	9.76 522	29	0.23 477	9.93 658	7 7	47	9 4.4 4.3 4.3
14	9.70 202	22	9.76 551	29	0.23 448	9.93 650	7 7	46	10 4.9 4.8 4.7
15	9.70 223	21	9.76 580	29	0.23 419	9.93 643	7 7	45	20 9.8 9.6 9.5
16	9.70 245	22	9.76 609	29	0.23 390	9.93 635	7 7	44	30 14.7 14.5 14.2
17	9.70 267	22	9.76 638	29	0.23 361	9.93 628	7 7	43	40 19.6 19.3 19.0
18	9.70 288	21	9.76 667	29	0.23 332	9.93 621	7 7	42	50 24.6 24.1 23.7
19	9.70 310	21	9.76 696	29	0.23 303	9.93 613	7 7	41	
20	9.70 331	21	9.76 725	29	0.23 274	9.93 606	7 7	40	
21	9.70 353	22	9.76 754	29	0.23 245	9.93 599	7 7	39	
22	9.70 375	22	9.76 783	29	0.23 216	9.93 591	7 7	38	
23	9.70 396	21	9.76 812	29	0.23 187	9.93 584	7 7	37	
24	9.70 418	22	9.76 841	29	0.23 158	9.93 576	7 7	36	
25	9.70 439	21	9.76 870	29	0.23 129	9.93 569	7 7	35	
26	9.70 461	22	9.76 899	29	0.23 101	9.93 562	7 7	34	22 21 21
27	9.70 482	21	9.76 928	29	0.23 072	9.93 554	7 7	33	6 2.2 2.1 2.1
28	9.70 504	22	9.76 957	29	0.23 043	9.93 547	7 7	32	7 2.5 2.5 2.4
29	9.70 525	21	9.76 986	29	0.23 014	9.93 539	7 7	31	8 2.9 2.8 2.8
30	9.70 547	22	9.77 015	29	0.22 985	9.93 532	7 7	30	9 3.3 3.2 3.1
31	9.70 568	21	9.77 043	28	0.22 956	9.93 524	7 7	29	10 3.6 3.6 3.5
32	9.70 590	22	9.77 072	29	0.22 927	9.93 517	7 7	28	20 7.3 7.1 7.0
33	9.70 611	21	9.77 101	29	0.22 898	9.93 509	7 7	27	30 11.0 10.7 10.5
34	9.70 632	21	9.77 130	29	0.22 869	9.93 502	7 7	26	40 14.6 14.3 14.0
35	9.70 654	22	9.77 159	28	0.22 841	9.93 495	7 7	25	50 18.3 17.9 17.5
36	9.70 675	21	9.77 188	29	0.22 812	9.93 487	7 7	24	
37	9.70 696	21	9.77 217	29	0.22 783	9.93 480	7 7	23	
38	9.70 718	22	9.77 245	28	0.22 754	9.93 472	7 7	22	
39	9.70 739	21	9.77 274	29	0.22 725	9.93 465	7 7	21	
40	9.70 760	21	9.77 303	29	0.22 696	9.93 457	7 7	20	
41	9.70 782	21	9.77 332	28	0.22 668	9.93 450	7 7	19	
42	9.70 803	21	9.77 361	29	0.22 639	9.93 442	7 7	18	
43	9.70 824	21	9.77 389	28	0.22 610	9.93 435	7 7	17	
44	9.70 846	21	9.77 418	29	0.22 581	9.93 427	7 7	16	8 7 7
45	9.70 867	21	9.77 447	28	0.22 553	9.93 420	7 7	15	6 0.8 0.7 0.7
46	9.70 888	21	9.77 476	29	0.22 524	9.93 412	7 7	14	7 0.9 0.9 0.8
47	9.70 909	21	9.77 504	28	0.22 495	9.93 405	7 7	13	8 1.0 1.0 0.9
48	9.70 930	21	9.77 533	29	0.22 466	9.93 397	7 7	12	9 1.2 1.1 1.0
49	9.70 952	21	9.77 562	28	0.22 438	9.93 390	7 7	11	10 1.3 1.2 1.1
50	9.70 973	21	9.77 591	29	0.22 409	9.93 382	8 7	10	20 2.6 2.5 2.3
51	9.70 994	21	9.77 619	28	0.22 380	9.93 374	7 7	9	30 4.0 3.7 3.5
52	9.71 015	21	9.77 648	29	0.22 352	9.93 367	7 7	8	40 5.3 5.0 4.6
53	9.71 036	21	9.77 677	29	0.22 323	9.93 359	7 7	7	50 6.6 6.2 5.8
54	9.71 057	21	9.77 705	28	0.22 294	9.93 352	7 7	6	
55	9.71 078	21	9.77 734	29	0.22 266	9.93 344	7 7	5	
56	9.71 099	21	9.77 763	29	0.22 237	9.93 337	7 7	4	
57	9.71 121	21	9.77 791	28	0.22 208	9.93 329	8 7	3	
58	9.71 142	21	9.77 820	29	0.22 180	9.93 321	8 7	2	
59	9.71 163	21	9.77 849	29	0.22 151	9.93 314	7 7	1	
60	9.71 184	21	9.77 877	28	0.22 122	9.93 306	8 7	0	
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

′	Log. Sin.	d.	Log. Tan.	c.d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9.71 184	21	9.77 877	28	0.22 122	9.93 306	7 7 7	60	
1	9.71 205	21	9.77 906	28	0.22 094	9.93 299		59	
2	9.71 226	21	9.77 934	28	0.22 065	9.93 291		58	
3	9.71 247	21	9.77 963	29	0.22 037	9.93 284	8	57	
4	9.71 268	21	9.77 992	28	0.22 008	9.93 276	8	56	
5	9.71 289	21	9.78 020	28	0.21 979	9.93 268	7 7 7	55	
6	9.71 310	21	9.78 049	28	0.21 951	9.93 261		54	
7	9.71 331	21	9.78 077	28	0.21 922	9.93 253		53	
8	9.71 351	20	9.78 106	28	0.21 894	9.93 245	8	52	
9	9.71 372	21	9.78 134	28	0.21 865	9.93 238	8	51	
10	9.71 393	21	9.78 163	28	0.21 837	9.93 230	7 7 7	50	
11	9.71 414	21	9.78 191	28	0.21 808	9.93 223		49	
12	9.71 435	20	9.78 220	28	0.21 780	9.93 215		48	
13	9.71 456	21	9.78 248	28	0.21 751	9.93 207	8	47	
14	9.71 477	21	9.78 277	28	0.21 723	9.93 200	7	46	
15	9.71 498	21	9.78 305	28	0.21 694	9.93 192	8 7 7	45	
16	9.71 518	20	9.78 334	28	0.21 666	9.93 184		44	
17	9.71 539	21	9.78 362	28	0.21 637	9.93 177		43	
18	9.71 560	21	9.78 391	28	0.21 609	9.93 169	8	42	
19	9.71 581	21	9.78 419	28	0.21 580	9.93 161	8	41	
20	9.71 601	20	9.78 448	28	0.21 552	9.93 153	8 7 7	40	
21	9.71 622	21	9.78 476	28	0.21 523	9.93 146		39	
22	9.71 643	20	9.78 505	28	0.21 495	9.93 138		38	
23	9.71 664	21	9.78 533	28	0.21 467	9.93 130	8	37	
24	9.71 684	20	9.78 561	28	0.21 438	9.93 123	8	36	
25	9.71 705	21	9.78 590	28	0.21 410	9.93 115	8 7 7	35	
26	9.71 726	20	9.78 618	28	0.21 381	9.93 107		34	
27	9.71 746	20	9.78 647	28	0.21 353	9.93 100		33	
28	9.71 767	21	9.78 675	28	0.21 325	9.93 092	8	32	
29	9.71 788	20	9.78 703	28	0.21 296	9.93 084	8	31	
30	9.71 808	20	9.78 732	28	0.21 268	9.93 076	8 7 7	30	
31	9.71 829	20	9.78 760	28	0.21 239	9.93 069		29	
32	9.71 849	21	9.78 788	28	0.21 211	9.93 061		28	
33	9.71 870	20	9.78 817	28	0.21 183	9.93 053	8	27	
34	9.71 891	20	9.78 845	28	0.21 154	9.93 045	7	26	
35	9.71 911	20	9.78 873	28	0.21 126	9.93 038	8 7 7	25	
36	9.71 932	20	9.78 902	28	0.21 098	9.93 030		24	
37	9.71 952	20	9.78 930	28	0.21 070	9.93 022		23	
38	9.71 973	20	9.78 958	28	0.21 041	9.93 014	8	22	
39	9.71 993	20	9.78 987	28	0.21 013	9.93 006	8	21	
40	9.72 014	20	9.79 015	28	0.20 985	9.92 999	7 8 7	20	
41	9.72 034	20	9.79 043	28	0.20 956	9.92 991		19	
42	9.72 055	20	9.79 071	28	0.20 928	9.92 983		18	
43	9.72 075	20	9.79 100	28	0.20 900	9.92 975	8	17	
44	9.72 096	20	9.79 128	28	0.20 872	9.92 967	8	16	
45	9.72 116	20	9.79 156	28	0.20 843	9.92 960	7 8 7	15	
46	9.72 136	20	9.79 184	28	0.20 815	9.92 952		14	
47	9.72 157	20	9.79 213	28	0.20 787	9.92 944		13	
48	9.72 177	20	9.79 241	28	0.20 759	9.92 936	8	12	
49	9.72 198	20	9.79 269	28	0.20 731	9.92 928	8	11	
50	9.72 218	20	9.79 297	28	0.20 702	9.92 920	8 7 7	10	
51	9.72 238	20	9.79 325	28	0.20 674	9.92 913		9	
52	9.72 259	20	9.79 354	28	0.20 646	9.92 905		8	
53	9.72 279	20	9.79 382	28	0.20 618	9.92 897	8	7	
54	9.72 299	20	9.79 410	28	0.20 590	9.92 889	8	6	
55	9.72 319	20	9.79 438	28	0.20 561	9.92 881	8 8 7	5	
56	9.72 340	20	9.79 466	28	0.20 533	9.92 873		4	
57	9.72 360	20	9.79 494	28	0.20 505	9.92 865		3	
58	9.72 380	20	9.79 522	28	0.20 477	9.92 858	8	2	
59	9.72 400	20	9.79 551	28	0.20 449	9.92 850	8	1	
60	9.72 421	20	9.79 579	28	0.20 421	9.92 842	8	0	
	Log. Cos.	d.	Log. Cot.	c.d.	Log. Tan.	Log. Sin.	d.	′	P. P.

	29	28	28
6	2.9	2.8	3.2
7	3.4	3.3	3.7
8	3.8	3.8	4.2
9	4.3	4.3	4.6
10	4.8	4.7	5.1
20	9.6	9.5	10.3
30	14.5	14.2	15.4
40	19.3	19.0	20.5
50	24.1	23.7	25.7

	21	20	20
6	2.1	2.0	2.0
7	2.4	2.4	2.3
8	2.8	2.7	2.6
9	3.1	3.1	3.0
10	3.5	3.4	3.3
20	7.0	6.8	6.6
30	10.5	10.2	10.0
40	14.0	13.6	13.3
50	17.5	17.1	16.6

	8	7
6	0.8	0.7
7	0.9	0.9
8	1.0	1.0
9	1.2	1.1
10	1.3	1.2
20	2.6	2.5
30	4.0	3.7
40	5.3	5.0
50	6.6	6.2

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9·72 421		9·79 579		0·20 421	9·92 842		60
1	9·72 441	20	9·79 607	28	0·20 393	9·92 834	8	59
2	9·72 461	20	9·79 635	28	0·20 365	9·92 826	7 8	58
3	9·72 481	20	9·79 663	28	0·20 337	9·92 818	8	57
4	9·72 501	20	9·79 691	28	0·20 308	9·92 810	8	56
5	9·72 522	20	9·79 719	28	0·20 280	9·92 802	8	55
6	9·72 542	20	9·79 747	28	0·20 252	9·92 794	8	54
7	9·72 562	20	9·79 775	28	0·20 224	9·92 786	8	53
8	9·72 582	20	9·79 803	28	0·20 196	9·92 778	8	52
9	9·72 602	20	9·79 831	28	0·20 168	9·92 771	7	51
10	9·72 622	20	9·79 859	28	0·20 140	9·92 763	8	50
1	9·72 642	20	9·79 887	28	0·20 112	9·92 755	8	49
2	9·72 662	20	9·79 915	28	0·20 084	9·92 747	8	48
3	9·72 682	20	9·79 943	28	0·20 056	9·92 739	8	47
4	9·72 702	20	9·79 971	28	0·20 028	9·92 731	8	46
5	9·72 723	20	9·79 999	28	0·20 000	9·92 723	8	45
6	9·72 743	20	9·80 027	28	0·19 972	9·92 715	8	44
7	9·72 763	20	9·80 055	28	0·19 944	9·92 707	8	43
8	9·72 783	20	9·80 083	28	0·19 916	9·92 699	8	42
9	9·72 802	19	9·80 111	28	0·19 888	9·92 691	8	41
20	9·72 822	20	9·80 139	28	0·19 860	9·92 683	8	40
1	9·72 842	20	9·80 167	28	0·19 832	9·92 675	8	39
2	9·72 862	20	9·80 195	28	0·19 804	9·92 667	8	38
3	9·72 882	20	9·80 223	28	0·19 776	9·92 659	8	37
4	9·72 902	20	9·80 251	28	0·19 748	9·92 651	8	36
5	9·72 922	20	9·80 279	27	0·19 721	9·92 643	8	35
6	9·72 942	19	9·80 307	28	0·19 693	9·92 635	8	34
7	9·72 962	20	9·80 335	28	0·19 665	9·92 627	8	33
8	9·72 982	20	9·80 363	28	0·19 637	9·92 619	8	32
9	9·73 002	20	9·80 391	28	0·19 609	9·92 611	8	31
30	9·73 021	19	9·80 418	27	0·19 581	9·92 603	8	30
1	9·73 041	20	9·80 446	28	0·19 553	9·92 595	8	29
2	9·73 061	20	9·80 474	28	0·19 525	9·92 587	8	28
3	9·73 081	19	9·80 502	28	0·19 497	9·92 579	8	27
4	9·73 101	20	9·80 530	27	0·19 470	9·92 570	8	26
5	9·73 120	19	9·80 558	28	0·19 442	9·92 562	8	25
6	9·73 140	20	9·80 586	28	0·19 414	9·92 554	8	24
7	9·73 160	19	9·80 613	27	0·19 386	9·92 546	8	23
8	9·73 180	20	9·80 641	28	0·19 358	9·92 538	8	22
9	9·73 199	19	9·80 669	28	0·19 330	9·92 530	8	21
0	9·73 219	20	9·80 697	28	0·19 303	9·92 522	8	20
1	9·73 239	19	9·80 725	28	0·19 275	9·92 514	8	19
2	9·73 258	19	9·80 752	27	0·19 247	9·92 506	8	18
3	9·73 278	20	9·80 780	28	0·19 219	9·92 498	8	17
4	9·73 298	19	9·80 808	28	0·19 191	9·92 489	8	16
5	9·73 317	19	9·80 836	28	0·19 164	9·92 481	8	15
6	9·73 337	20	9·80 864	28	0·19 136	9·92 473	8	14
7	9·73 357	19	9·80 891	27	0·19 108	9·92 465	8	13
8	9·73 376	19	9·80 919	28	0·19 080	9·92 457	8	12
9	9·73 396	19	9·80 947	28	0·19 053	9·92 449	8	11
0	9·73 415	19	9·80 975	28	0·19 025	9·92 441	8	10
1	9·73 435	20	9·81 002	27	0·18 997	9·92 433	8	9
2	9·73 455	19	9·81 030	28	0·18 970	9·92 424	8	8
3	9·73 474	19	9·81 058	28	0·18 942	9·92 416	8	7
4	9·73 494	19	9·81 085	27	0·18 914	9·92 408	8	6
5	9·73 513	19	9·81 113	28	0·18 886	9·92 400	8	5
6	9·73 533	19	9·81 141	28	0·18 859	9·92 392	8	4
7	9·73 552	19	9·81 168	27	0·18 831	9·92 383	8	3
8	9·73 572	19	9·81 196	28	0·18 803	9·92 375	8	2
9	9·73 591	19	9·81 224	28	0·18 776	9·92 367	8	1
0	9·73 611	19	9·81 251	27	0·18 748	9·92 359	8	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	28	28	27	
6	2·8	2·8	2·7	
7	3·3	3·2	3·2	
8	3·8	3·7	3·6	
9	4·3	4·2	4·1	
10	4·7	4·6	4·6	
20	9·5	9·3	9·1	
30	14·2	14·0	13·7	
40	19·0	18·6	18·3	
50	23·7	23·3	22·9	

	20	20	19
6	2·0	2·0	1·9
7	2·4	2·3	2·3
8	2·7	2·6	2·6
9	3·1	3·0	2·9
10	3·4	3·3	3·2
20	6·8	6·6	6·5
30	10·2	10·0	9·7
40	13·6	13·3	13·0
50	17·1	16·6	16·2

	8	8	7
6	0·8	0·8	0·7
7	1·0	0·9	0·9
8	1·1	1·0	1·0
9	1·3	1·2	1·1
10	1·4	1·3	1·2
20	2·8	2·6	2·5
30	4·2	4·0	3·7
40	5·6	5·3	5·0
50	7·1	6·6	6·2

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
0	9.73 611	19	9.81 251	28	0.18 748	9.92 359	8	60
1	9.73 630	19	9.81 279	27	0.18 720	9.92 351	8	59
2	9.73 650	19	9.81 307	27	0.18 693	9.92 342	8	58
3	9.73 669	19	9.81 334	28	0.18 665	9.92 334	8	57
4	9.73 688	19	9.81 362	27	0.18 637	9.92 326	8	56
5	9.73 708	19	9.81 390	27	0.18 610	9.92 318	8	55
6	9.73 727	19	9.81 417	27	0.18 582	9.92 310	8	54
7	9.73 746	19	9.81 445	28	0.18 555	9.92 301	8	53
8	9.73 766	19	9.81 473	27	0.18 527	9.92 293	8	52
9	9.73 785	19	9.81 500	27	0.18 499	9.92 285	8	51
10	9.73 805	19	9.81 528	27	0.18 472	9.92 277	8	50
11	9.73 824	19	9.81 555	27	0.18 444	9.92 268	8	49
12	9.73 843	19	9.81 583	27	0.18 417	9.92 260	8	48
13	9.73 862	19	9.81 610	27	0.18 389	9.92 252	8	47
14	9.73 882	19	9.81 638	28	0.18 362	9.92 244	8	46
15	9.73 901	19	9.81 666	27	0.18 334	9.92 235	8	45
16	9.73 920	19	9.81 693	27	0.18 306	9.92 227	8	44
17	9.73 940	19	9.81 721	27	0.18 279	9.92 219	8	43
18	9.73 959	19	9.81 748	27	0.18 251	9.92 210	8	42
19	9.73 978	19	9.81 776	27	0.18 224	9.92 202	8	41
20	9.73 997	19	9.81 803	27	0.18 196	9.92 194	8	40
21	9.74 016	19	9.81 831	27	0.18 169	9.92 185	8	39
22	9.74 036	19	9.81 858	27	0.18 141	9.92 177	8	38
23	9.74 055	19	9.81 886	27	0.18 114	9.92 169	8	37
24	9.74 074	19	9.81 913	27	0.18 086	9.92 160	8	36
25	9.74 093	19	9.81 941	27	0.18 059	9.92 152	8	35
26	9.74 112	19	9.81 968	27	0.18 031	9.92 144	8	34
27	9.74 131	19	9.81 996	27	0.18 004	9.92 135	8	33
28	9.74 151	19	9.82 023	27	0.17 976	9.92 127	8	32
29	9.74 170	19	9.82 051	27	0.17 949	9.92 119	8	31
30	9.74 189	19	9.82 078	27	0.17 921	9.92 110	8	30
31	9.74 208	19	9.82 105	27	0.17 894	9.92 102	8	29
32	9.74 227	19	9.82 133	27	0.17 867	9.92 094	8	28
33	9.74 246	19	9.82 160	27	0.17 839	9.92 085	8	27
34	9.74 265	19	9.82 188	27	0.17 812	9.92 077	8	26
35	9.74 284	19	9.82 215	27	0.17 784	9.92 069	8	25
36	9.74 303	19	9.82 243	27	0.17 757	9.92 060	8	24
37	9.74 322	19	9.82 270	27	0.17 729	9.92 052	8	23
38	9.74 341	18	9.82 297	27	0.17 702	9.92 043	8	22
39	9.74 360	19	9.82 325	27	0.17 675	9.92 035	8	21
40	9.74 379	19	9.82 352	27	0.17 647	9.92 027	8	20
41	9.74 398	19	9.82 380	27	0.17 620	9.92 018	8	19
42	9.74 417	19	9.82 407	27	0.17 593	9.92 010	8	18
43	9.74 436	19	9.82 434	27	0.17 565	9.92 001	8	17
44	9.74 455	19	9.82 462	27	0.17 538	9.91 993	8	16
45	9.74 474	19	9.82 489	27	0.17 510	9.91 984	8	15
46	9.74 493	18	9.82 516	27	0.17 483	9.91 976	8	14
47	9.74 511	19	9.82 544	27	0.17 456	9.91 967	8	13
48	9.74 530	19	9.82 571	27	0.17 428	9.91 959	8	12
49	9.74 549	19	9.82 598	27	0.17 401	9.91 951	8	11
50	9.74 568	19	9.82 626	27	0.17 374	9.91 942	8	10
51	9.74 587	18	9.82 653	27	0.17 347	9.91 934	8	9
52	9.74 606	19	9.82 680	27	0.17 319	9.91 925	8	8
53	9.74 625	19	9.82 708	27	0.17 292	9.91 917	8	7
54	9.74 643	18	9.82 735	27	0.17 265	9.91 908	8	6
55	9.74 662	19	9.82 762	27	0.17 237	9.91 900	8	5
56	9.74 681	19	9.82 789	27	0.17 210	9.91 891	8	4
57	9.74 700	19	9.82 817	27	0.17 183	9.91 883	8	3
58	9.74 718	18	9.82 844	27	0.17 156	9.91 874	8	2
59	9.74 737	19	9.82 871	27	0.17 128	9.91 866	8	1
60	9.74 756	18	9.82 898	27	0.17 101	9.91 857	8	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	28	27	27
6	2.8	2.7	2.7
7	3.2	3.2	3.1
8	3.7	3.6	3.6
9	4.2	4.1	4.0
10	4.6	4.6	4.5
20	9.3	9.1	9.0
30	14.0	13.7	13.5
40	18.6	18.3	18.0
50	23.3	22.9	22.5

P. P.

	19	19	18
6	1.9	1.9	1.8
7	2.3	2.2	2.1
8	2.6	2.5	2.4
9	2.9	2.8	2.8
10	3.2	3.1	3.1
20	6.5	6.3	6.1
30	9.7	9.5	9.2
40	13.0	12.6	12.3
50	16.2	15.8	15.4

P. P.

	8	8
6	0.8	0.8
7	1.0	0.9
8	1.1	1.0
9	1.3	1.2
10	1.4	1.3
20	2.8	2.5
30	4.2	4.0
40	5.6	5.3
50	7.1	6.8

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
34°								145°
0	9.74 756	19	9.82 898	27	0.17 101	9.91 857	3	60
1	9.74 775	18	9.82 926	27	0.17 074	9.91 849	3	59
2	9.74 793	19	9.82 953	27	0.17 047	9.91 840	3	58
3	9.74 812	18	9.82 980	27	0.17 019	9.91 832	3	57
4	9.74 831	18	9.83 007	27	0.16 992	9.91 823	3	56
5	9.74 849	18	9.83 035	27	0.16 965	9.91 814	3	55
6	9.74 868	19	9.83 062	27	0.16 938	9.91 806	3	54
7	9.74 887	18	9.83 089	27	0.16 910	9.91 797	3	53
8	9.74 905	18	9.83 116	27	0.16 883	9.91 789	3	52
9	9.74 924	19	9.83 143	27	0.16 856	9.91 780	3	51
10	9.74 943	18	9.83 171	27	0.16 829	9.91 772	3	50
1	9.74 961	18	9.83 198	27	0.16 802	9.91 763	3	49
2	9.74 980	18	9.83 225	27	0.16 774	9.91 755	3	48
3	9.74 998	18	9.83 252	27	0.16 747	9.91 746	3	47
4	9.75 017	19	9.83 279	27	0.16 720	9.91 737	3	46
5	9.75 036	18	9.83 307	27	0.16 693	9.91 729	3	45
6	9.75 054	18	9.83 334	27	0.16 666	9.91 720	3	44
7	9.75 073	18	9.83 361	27	0.16 639	9.91 712	3	43
8	9.75 091	18	9.83 388	27	0.16 612	9.91 703	3	42
9	9.75 110	18	9.83 415	27	0.16 584	9.91 694	3	41
20	9.75 128	18	9.83 442	27	0.16 557	9.91 686	3	40
1	9.75 147	18	9.83 469	27	0.16 530	9.91 677	3	39
2	9.75 165	18	9.83 496	27	0.16 503	9.91 668	3	38
3	9.75 184	18	9.83 524	27	0.16 476	9.91 660	3	37
4	9.75 202	18	9.83 551	27	0.16 449	9.91 651	3	36
5	9.75 221	18	9.83 578	27	0.16 422	9.91 642	3	35
6	9.75 239	18	9.83 605	27	0.16 395	9.91 634	3	34
7	9.75 257	18	9.83 632	27	0.16 368	9.91 625	3	33
8	9.75 276	18	9.83 659	27	0.16 340	9.91 616	3	32
9	9.75 294	18	9.83 686	27	0.16 313	9.91 608	3	31
30	9.75 313	18	9.83 713	27	0.16 286	9.91 599	3	30
1	9.75 331	18	9.83 740	27	0.16 259	9.91 590	3	29
2	9.75 349	18	9.83 767	27	0.16 232	9.91 582	3	28
3	9.75 368	18	9.83 794	27	0.16 205	9.91 573	3	27
4	9.75 386	18	9.83 821	27	0.16 178	9.91 564	3	26
5	9.75 404	18	9.83 848	27	0.16 151	9.91 556	3	25
6	9.75 423	18	9.83 875	27	0.16 124	9.91 547	3	24
7	9.75 441	18	9.83 902	27	0.16 097	9.91 538	3	23
8	9.75 459	18	9.83 929	27	0.16 070	9.91 525	3	22
9	9.75 478	18	9.83 957	27	0.16 043	9.91 521	3	21
40	9.75 496	18	9.83 984	27	0.16 016	9.91 512	3	20
1	9.75 514	18	9.84 011	27	0.15 989	9.91 503	3	19
2	9.75 532	18	9.84 038	27	0.15 962	9.91 495	3	18
3	9.75 551	18	9.84 065	26	0.15 935	9.91 486	3	17
4	9.75 569	18	9.84 091	27	0.15 908	9.91 477	3	16
5	9.75 587	18	9.84 118	27	0.15 881	9.91 468	3	15
6	9.75 605	18	9.84 145	27	0.15 854	9.91 460	3	14
7	9.75 623	18	9.84 172	27	0.15 827	9.91 451	3	13
8	9.75 642	18	9.84 199	27	0.15 800	9.91 442	3	12
9	9.75 660	18	9.84 226	27	0.15 773	9.91 433	3	11
50	9.75 678	18	9.84 253	27	0.15 746	9.91 424	3	10
1	9.75 696	18	9.84 280	27	0.15 719	9.91 416	3	9
2	9.75 714	18	9.84 307	27	0.15 692	9.91 407	3	8
3	9.75 732	18	9.84 334	27	0.15 665	9.91 398	3	7
4	9.75 750	18	9.84 361	26	0.15 639	9.91 389	3	6
5	9.75 769	18	9.84 388	27	0.15 612	9.91 380	3	5
6	9.75 787	18	9.84 415	27	0.15 585	9.91 372	3	4
7	9.75 805	18	9.84 442	27	0.15 558	9.91 363	3	3
8	9.75 823	18	9.84 469	27	0.15 531	9.91 354	3	2
9	9.75 841	18	9.84 496	27	0.15 504	9.91 345	3	1
60	9.75 859	18	9.84 522	26	0.15 477	9.91 336	3	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	27	27	26
6	2.7	2.7	2.6
7	3.2	3.1	3.1
8	3.6	3.6	3.5
9	4.1	4.0	4.0
10	4.6	4.5	4.4
20	9.1	9.0	8.8
30	13.7	13.5	13.2
40	18.3	18.0	17.6
50	22.9	22.5	22.1

	19	18	18
6	1.9	1.8	1.8
7	2.2	2.1	2.1
8	2.5	2.4	2.4
9	2.8	2.8	2.7
10	3.1	3.1	3.0
20	6.3	6.1	6.0
30	9.5	9.2	9.0
40	12.6	12.3	12.0
50	15.8	15.4	15.0

	9	8
6	0.9	0.8
7	1.0	1.0
8	1.2	1.1
9	1.3	1.3
10	1.5	1.4
20	3.0	2.8
30	4.5	4.2
40	6.0	5.6
50	7.5	7.1

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9·75 859	18	9·84 522	27	0·15 477	9·91 336	9	60	
1	9·75 877	18	9·84 549	27	0·15 450	9·91 327	9	59	
2	9·75 895	18	9·84 576	27	0·15 423	9·91 318	9	58	
3	9·75 913	18	9·84 603	27	0·15 396	9·91 310	9	57	
4	9·75 931	18	9·84 630	26	0·15 370	9·91 301	9	56	
5	9·75 949	18	9·84 657	27	0·15 343	9·91 292	9	55	
6	9·75 967	18	9·84 684	27	0·15 316	9·91 283	9	54	
7	9·75 985	18	9·84 711	27	0·15 289	9·91 274	9	53	
8	9·76 003	18	9·84 737	26	0·15 262	9·91 265	9	52	
9	9·76 021	18	9·84 764	27	0·15 235	9·91 256	9	51	
10	9·76 039	18	9·84 791	27	0·15 208	9·91 247	9	50	
11	9·76 057	18	9·84 818	27	0·15 182	9·91 239	9	49	
12	9·76 075	17	9·84 845	26	0·15 155	9·91 230	9	48	
13	9·76 092	18	9·84 871	27	0·15 128	9·91 221	9	47	
14	9·76 110	18	9·84 898	27	0·15 101	9·91 212	9	46	
15	9·76 128	18	9·84 925	27	0·15 074	9·91 203	9	45	
16	9·76 146	18	9·84 952	26	0·15 048	9·91 194	9	44	
17	9·76 164	18	9·84 979	27	0·15 021	9·91 185	9	43	
18	9·76 182	18	9·85 005	26	0·14 994	9·91 176	9	42	
19	9·76 200	17	9·85 032	27	0·14 967	9·91 167	9	41	
20	9·76 217	18	9·85 059	27	0·14 940	9·91 158	9	40	
21	9·76 235	18	9·85 086	26	0·14 914	9·91 149	9	39	
22	9·76 253	17	9·85 113	27	0·14 887	9·91 140	9	38	
23	9·76 271	18	9·85 139	26	0·14 860	9·91 131	9	37	
24	9·76 289	17	9·85 166	27	0·14 833	9·91 122	9	36	
25	9·76 306	18	9·85 193	27	0·14 807	9·91 113	9	35	
26	9·76 324	17	9·85 220	27	0·14 780	9·91 104	9	34	
27	9·76 342	18	9·85 246	26	0·14 753	9·91 095	9	33	
28	9·76 360	17	9·85 273	27	0·14 726	9·91 086	9	32	
29	9·76 377	17	9·85 300	26	0·14 700	9·91 077	9	31	
30	9·76 395	18	9·85 327	27	0·14 673	9·91 068	9	30	
31	9·76 413	18	9·85 353	26	0·14 646	9·91 059	9	29	
32	9·76 431	17	9·85 380	27	0·14 620	9·91 050	9	28	
33	9·76 448	17	9·85 407	27	0·14 593	9·91 041	9	27	
34	9·76 466	17	9·85 433	26	0·14 566	9·91 032	9	26	
35	9·76 484	18	9·85 460	27	0·14 539	9·91 023	9	25	
36	9·76 501	17	9·85 487	26	0·14 513	9·91 014	9	24	
37	9·76 519	17	9·85 513	27	0·14 486	9·91 005	9	23	
38	9·73 536	17	9·85 540	27	0·14 459	9·90 996	9	22	
39	9·76 554	18	9·85 567	26	0·14 433	9·90 987	9	21	
40	9·76 572	17	9·85 594	27	0·14 406	9·90 978	9	20	
41	9·76 589	17	9·85 620	26	0·14 379	9·90 969	9	19	
42	9·76 607	17	9·85 647	26	0·14 353	9·90 960	9	18	
43	9·76 624	17	9·85 673	26	0·14 326	9·90 951	9	17	
44	9·76 642	18	9·85 700	27	0·14 299	9·90 942	9	16	
45	9·76 660	17	9·85 727	26	0·14 273	9·90 933	9	15	
46	9·76 677	17	9·85 753	26	0·14 246	9·90 923	9	14	
47	9·76 695	17	9·85 780	27	0·14 219	9·90 914	9	13	
48	9·76 712	17	9·85 807	26	0·14 193	9·90 905	9	12	
49	9·76 730	17	9·85 833	26	0·14 166	9·90 896	9	11	
50	9·76 747	17	9·85 860	27	0·14 140	9·90 887	9	10	
51	9·76 765	17	9·85 887	26	0·14 113	9·90 878	9	9	
52	9·76 782	17	9·85 913	26	0·14 086	9·90 869	9	8	
53	9·76 800	17	9·85 940	26	0·14 060	9·90 860	9	7	
54	9·76 817	17	9·85 966	26	0·14 033	9·90 850	9	6	
55	9·76 835	17	9·85 993	27	0·14 007	9·90 841	9	5	
56	9·76 852	17	9·86 020	26	0·13 980	9·90 832	9	4	
57	9·76 869	17	9·86 046	26	0·13 953	9·90 823	9	3	
58	9·76 887	17	9·86 073	26	0·13 927	9·90 814	9	2	
59	9·76 904	17	9·86 099	26	0·13 900	9·90 805	9	1	
60	9·76 922	17	9·86 126	26	0·13 874	9·90 796	9	0	
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

	27	26
6	2·7	2·6
7	3·1	3·1
8	3·6	3·5
9	4·0	4·0
10	4·5	4·4
20	9·0	8·8
30	13·5	13·2
40	18·0	17·6
50	22·5	22·1

	18	17	17
6	1·8	1·7	1·7
7	2·1	2·0	2·0
8	2·4	2·3	2·2
9	2·7	2·6	2·5
10	3·0	2·9	2·8
20	6·0	5·8	5·6
30	9·0	8·7	8·5
40	12·0	11·6	11·3
50	15·0	14·6	14·1

	9	9	8
6	0·9	0·9	0·8
7	1·1	1·0	1·0
8	1·2	1·2	1·1
9	1·4	1·3	1·3
10	1·6	1·5	1·4
20	3·1	3·0	2·8
30	4·7	4·5	4·2
40	6·3	6·0	5·6
50	7·9	7·5	7·1

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9·76 922	17	9·86 126	26	0·13 874	9·90 796	9	60
1	9·76 939	17	9·86 152	26	0·13 847	9·90 786	9	59
2	9·76 956	17	9·86 179	27	0·13 821	9·90 777	9	58
3	9·76 974	17	9·86 206	26	0·13 794	9·90 768	9	57
4	9·76 991	17	9·86 232	26	0·13 767	9·90 759	9	56
5	9·77 008	17	9·86 259	26	0·13 741	9·90 750	9	55
6	9·77 026	17	9·86 285	26	0·13 714	9·90 740	9	54
7	9·77 043	17	9·86 312	26	0·13 688	9·90 731	9	53
8	9·77 060	17	9·86 338	26	0·13 661	9·90 722	9	52
9	9·77 078	17	9·86 365	26	0·13 635	9·90 713	9	51
10	9·77 095	17	9·86 391	26	0·13 608	9·90 703	9	50
11	9·77 112	17	9·86 418	26	0·13 582	9·90 694	9	49
12	9·77 130	17	9·86 444	26	0·13 555	9·90 685	9	48
13	9·77 147	17	9·86 471	26	0·13 529	9·90 676	9	47
14	9·77 164	17	9·86 497	26	0·13 502	9·90 666	9	46
15	9·77 181	17	9·86 524	26	0·13 476	9·90 657	9	45
16	9·77 198	17	9·86 550	26	0·13 449	9·90 648	9	44
17	9·77 216	17	9·86 577	26	0·13 423	9·90 639	9	43
18	9·77 233	17	9·86 603	26	0·13 396	9·90 629	9	42
19	9·77 250	17	9·86 630	26	0·13 370	9·90 620	9	41
20	9·77 267	17	9·86 656	26	0·13 343	9·90 611	9	40
21	9·77 284	17	9·86 683	26	0·13 317	9·90 602	9	39
22	9·77 302	17	9·86 709	26	0·13 290	9·90 592	9	38
23	9·77 319	17	9·86 736	26	0·13 264	9·90 583	9	37
24	9·77 336	17	9·86 762	26	0·13 237	9·90 574	9	36
25	9·77 353	17	9·86 788	26	0·13 211	9·90 564	9	35
26	9·77 370	17	9·86 815	26	0·13 185	9·90 555	9	34
27	9·77 387	17	9·86 841	26	0·13 158	9·90 546	9	33
28	9·77 404	17	9·86 868	26	0·13 132	9·90 536	9	32
29	9·77 421	17	9·86 894	26	0·13 105	9·90 527	9	31
30	9·77 439	17	9·86 921	26	0·13 079	9·90 518	9	30
31	9·77 456	17	9·86 947	26	0·13 052	9·90 508	9	29
32	9·77 473	17	9·86 973	26	0·13 026	9·90 499	9	28
33	9·77 490	17	9·87 000	26	0·13 000	9·90 490	9	27
34	9·77 507	17	9·87 026	26	0·12 973	9·90 480	9	26
35	9·77 524	17	9·87 053	26	0·12 947	9·90 471	9	25
36	9·77 541	17	9·87 079	26	0·12 920	9·90 461	9	24
37	9·77 558	17	9·87 105	26	0·12 894	9·90 452	9	23
38	9·77 575	17	9·87 132	26	0·12 868	9·90 443	9	22
39	9·77 592	17	9·87 158	26	0·12 841	9·90 433	9	21
40	9·77 609	17	9·87 185	26	0·12 815	9·90 424	9	20
41	9·77 626	17	9·87 211	26	0·12 789	9·90 414	9	19
42	9·77 643	17	9·87 237	26	0·12 762	9·90 405	9	18
43	9·77 660	17	9·87 264	26	0·12 736	9·90 396	9	17
44	9·77 677	17	9·87 290	26	0·12 709	9·90 386	9	16
45	9·77 693	16	9·87 316	26	0·12 683	9·90 377	9	15
46	9·77 710	17	9·87 343	26	0·12 657	9·90 367	9	14
47	9·77 727	17	9·87 369	26	0·12 631	9·90 358	9	13
48	9·77 744	17	9·87 395	26	0·12 604	9·90 348	9	12
49	9·77 761	17	9·87 422	26	0·12 578	9·90 339	9	11
50	9·77 778	16	9·87 448	26	0·12 551	9·90 330	9	10
51	9·77 795	17	9·87 474	26	0·12 525	9·90 320	9	9
52	9·77 812	17	9·87 501	26	0·12 499	9·90 311	9	8
53	9·77 828	16	9·87 527	26	0·12 472	9·90 301	9	7
54	9·77 845	17	9·87 553	26	0·12 446	9·90 292	9	6
55	9·77 862	17	9·87 580	26	0·12 420	9·90 282	9	5
56	9·77 879	16	9·87 606	26	0·12 393	9·90 273	9	4
57	9·77 896	17	9·87 632	26	0·12 367	9·90 263	9	3
58	9·77 913	17	9·87 659	26	0·12 341	9·90 254	9	2
59	9·77 929	16	9·87 685	26	0·12 315	9·90 244	9	1
60	9·77 946	17	9·87 711	26	0·12 288	9·90 235	9	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	27	26	26
6	2·7	2·6	2·6
7	3·1	3·1	3·0
8	3·6	3·5	3·4
9	4·0	4·0	3·9
10	4·5	4·4	4·3
20	9·0	8·8	8·6
30	13·5	13·2	13·0
40	18·0	17·6	17·3
50	22·5	22·1	21·6

	17	17	16
6	1·7	1·7	1·6
7	2·0	2·0	1·9
8	2·3	2·2	2·2
9	2·6	2·5	2·5
10	2·9	2·8	2·7
20	5·8	5·6	5·5
30	8·7	8·5	8·2
40	11·6	11·3	11·0
50	14·6	14·1	13·7

	9	9
6	0·9	0·9
7	1·1	1·0
8	1·2	1·2
9	1·4	1·3
10	1·6	1·5
20	3·1	3·0
30	4·7	4·5
40	6·3	6·0
50	7·9	7·5

P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9.77 946	16	9.87 71[1]	26	0.12 28[8]	9.90 235	5	60	
1	9.77 963	17	9.87 737	26	0.12 262	9.90 225	5	59	
2	9.77 980	16	9.87 764	26	0.12 236	9.90 216	9	58	
3	9.77 996	17	9.87 790	26	0.12 209	9.90 206	10	57	
4	9.78 013	17	9.87 816	26	0.12 183	9.90 196	10	56	
5	9.78 030	16	9.87 843	26	0.12 157	9.90 187	9	55	
6	9.78 046	16	9.87 869	26	0.12 131	9.90 177	10	54	
7	9.78 063	17	9.87 895	26	0.12 104	9.90 168	9	53	
8	9.78 080	17	9.87 921	26	0.12 078	9.90 158	10	52	
9	9.78 097	16	9.87 948	26	0.12 052	9.90 149	9	51	26 26
10	9.78 113	16	9.87 974	26	0.12 026	9.90 139	10	50	6 2.6 2.6
11	9.78 130	17	9.88 000	26	0.11 999	9.90 130	9	49	7 3.1 3.0
12	9.78 147	16	9.88 026	26	0.11 973	9.90 120	10	48	8 3.5 3.4
13	9.78 163	16	9.88 053	26	0.11 947	9.90 110	10	47	9 4.0 3.9
14	9.78 180	16	9.88 079	26	0.11 921	9.90 101	9	46	10 4.4 4.3
15	9.78 196	16	9.88 105	26	0.11 895	9.90 091	10	45	20 8.8 8.6
16	9.78 213	17	9.88 131	26	0.11 868	9.90 082	9	44	30 13.2 13.0
17	9.78 230	17	9.88 157	26	0.11 842	9.90 072	10	43	40 17.6 17.3
18	9.78 246	16	9.88 184	26	0.11 816	9.90 062	10	42	50 22.1 21.6
19	9.78 263	16	9.88 210	26	0.11 790	9.90 053	9	41	
20	9.78 279	16	9.88 236	26	0.11 763	9.90 043	10	40	
21	9.78 296	16	9.88 262	26	0.11 737	9.90 033	10	39	
22	9.78 312	16	9.88 288	26	0.11 711	9.90 024	9	38	
23	9.78 329	17	9.88 315	26	0.11 685	9.90 014	10	37	
24	9.78 346	16	9.88 341	26	0.11 659	9.90 004	10	36	
25	9.78 362	16	9.88 367	26	0.11 633	9.89 995	9	35	
26	9.78 379	16	9.88 393	26	0.11 606	9.89 985	10	34	17 16 16
27	9.78 395	16	9.88 419	26	0.11 580	9.89 975	10	33	6 1.7 1.6 1.6
28	9.78 412	16	9.88 445	26	0.11 554	9.89 966	9	32	7 2.0 1.9 1.8
29	9.78 428	16	9.88 472	26	0.11 528	9.89 956	10	31	8 2.2 2.2 2.1
30	9.78 444	16	9.88 498	26	0.11 502	9.89 946	10	30	9 2.5 2.5 2.4
31	9.78 461	16	9.88 524	26	0.11 476	9.89 937	9	29	10 2.8 2.7 2.6
32	9.78 477	16	9.88 550	26	0.11 449	9.89 927	10	28	20 5.6 5.5 5.3
33	9.78 494	16	9.88 576	26	0.11 423	9.89 917	10	27	30 8.5 8.2 8.0
34	9.78 510	16	9.88 602	26	0.11 397	9.89 908	9	26	40 11.3 11.0 10.6
35	9.78 527	16	9.88 629	26	0.11 371	9.89 898	10	25	50 14.1 13.7 13.3
36	9.78 543	16	9.88 655	26	0.11 345	9.89 888	10	24	
37	9.78 559	16	9.88 681	26	0.11 319	9.89 878	9	23	
38	9.78 576	16	9.88 707	26	0.11 293	9.89 869	10	22	
39	9.78 592	16	9.88 733	26	0.11 266	9.89 859	10	21	
40	9.78 609	16	9.88 759	26	0.11 240	9.89 849	9	20	
41	9.78 625	16	9.88 785	26	0.11 214	9.89 839	10	19	
42	9.78 641	16	9.88 811	26	0.11 188	9.89 830	10	18	
43	9.78 658	16	9.88 838	26	0.11 162	9.89 820	10	17	
44	9.78 674	16	9.88 864	26	0.11 136	9.89 810	10	16	
45	9.78 690	16	9.88 890	26	0.11 110	9.89 800	10	15	10 9
46	9.78 707	16	9.88 916	26	0.11 084	9.89 791	9	14	6 1.0 0.9
47	9.78 723	16	9.88 942	26	0.11 058	9.89 781	10	13	7 1.1 1.1
48	9.78 739	16	9.88 968	26	0.11 032	9.89 771	10	12	8 1.3 1.2
49	9.78 755	16	9.88 994	26	0.11 005	9.89 761	10	11	9 1.5 1.4
50	9.78 772	16	9.89 020	26	0.10 979	9.89 751	10	10	10 1.6 1.6
51	9.78 788	16	9.89 046	26	0.10 953	9.89 742	9	9	20 3.3 3.1
52	9.78 804	16	9.89 072	26	0.10 927	9.89 732	10	8	30 5.0 4.7
53	9.78 821	16	9.89 098	26	0.10 901	9.89 722	10	7	40 6.6 6.3
54	9.78 837	16	9.89 124	26	0.10 875	9.89 712	10	6	50 8.3 7.9
55	9.78 853	16	9.89 150	26	0.10 849	9.89 702	10	5	
56	9.78 869	16	9.89 177	26	0.10 823	9.89 692	10	4	
57	9.78 885	16	9.89 203	26	0.10 797	9.89 683	9	3	
58	9.78 902	16	9.89 229	26	0.10 771	9.89 673	10	2	
59	9.78 918	16	9.89 255	26	0.10 745	9.89 663	10	1	
60	9.78 934	16	9.89 281	26	0.10 719	9.89 653	10	0	
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9.78 934	16	9.89 281	26	0.10 719	9.89 653	3	60	
1	9.78 950	16	9.89 307	26	0.10 693	9.89 643	10	59	
2	9.78 966	16	9.89 333	26	0.10 667	9.89 633	10	58	
3	9.78 982	16	9.89 359	26	0.10 641	9.89 623	10	57	
4	9.78 999	16	9.89 385	26	0.10 615	9.89 613	10	56	
5	9.79 015	16	9.89 411	26	0.10 589	9.89 604	3	55	
6	9.79 031	16	9.89 437	26	0.10 563	9.89 594	10	54	
7	9.79 047	16	9.89 463	26	0.10 537	9.89 584	10	53	
8	9.79 063	16	9.89 489	26	0.10 511	9.89 574	10	52	
9	9.79 079	16	9.89 515	26	0.10 485	9.89 564	10	51	
10	9.79 095	16	9.89 541	26	0.10 459	9.89 554	3	50	
11	9.79 111	16	9.89 567	26	0.10 433	9.89 544	10	49	
12	9.79 127	16	9.89 593	26	0.10 407	9.89 534	10	48	
13	9.79 143	16	9.89 619	26	0.10 381	9.89 524	10	47	
14	9.79 159	16	9.89 645	26	0.10 355	9.89 514	10	46	
15	9.79 175	16	9.89 671	26	0.10 329	9.89 504	10	45	
16	9.79 191	16	9.89 697	26	0.10 303	9.89 494	10	44	
17	9.79 207	16	9.89 723	26	0.10 277	9.89 484	10	43	
18	9.79 223	16	9.89 749	26	0.10 251	9.89 474	10	42	
19	9.79 239	16	9.89 775	26	0.10 225	9.89 464	10	41	
20	9.79 255	16	9.89 801	26	0.10 199	9.89 454	10	40	
21	9.79 271	16	9.89 827	26	0.10 173	9.89 444	10	39	
22	9.79 287	16	9.89 853	26	0.10 147	9.89 434	10	38	
23	9.79 303	16	9.89 879	26	0.10 121	9.89 424	10	37	
24	9.79 319	16	9.89 905	26	0.10 095	9.89 414	10	36	
25	9.79 335	16	9.89 931	26	0.10 069	9.89 404	10	35	
26	9.79 351	16	9.89 957	26	0.10 043	9.89 394	10	34	
27	9.79 367	16	9.89 982	25	0.10 017	9.89 384	10	33	
28	9.79 383	16	9.90 008	26	0.09 991	9.89 374	10	32	
29	9.79 399	16	9.90 034	26	0.09 965	9.89 364	10	31	
30	9.79 415	16	9.90 060	26	0.09 939	9.89 354	10	30	
31	9.79 431	16	9.90 086	26	0.09 913	9.89 344	10	29	
32	9.79 446	15	9.90 112	26	0.09 887	9.89 334	10	28	
33	9.79 462	16	9.90 138	26	0.09 861	9.89 324	10	27	
34	9.79 478	16	9.90 164	25	0.09 836	9.89 314	10	26	
35	9.79 494	15	9.90 190	26	0.09 810	9.89 304	10	25	
36	9.79 510	16	9.90 216	26	0.09 784	9.89 294	10	24	
37	9.79 526	16	9.90 242	26	0.09 758	9.89 284	10	23	
38	9.79 541	15	9.90 268	26	0.09 732	9.89 274	10	22	
39	9.79 557	16	9.90 294	26	0.09 706	9.89 264	10	21	
40	9.79 573	16	9.90 319	25	0.09 680	9.89 253	10	20	
41	9.79 589	15	9.90 345	26	0.09 654	9.89 243	10	19	
42	9.79 605	16	9.90 371	26	0.09 628	9.89 233	10	18	
43	9.79 620	15	9.90 397	26	0.09 602	9.89 223	10	17	
44	9.79 636	16	9.90 423	25	0.09 577	9.89 213	10	16	
45	9.79 652	15	9.90 449	26	0.09 551	9.89 203	10	15	
46	9.79 668	16	9.90 475	26	0.09 525	9.89 193	10	14	
47	9.79 683	15	9.90 501	26	0.09 499	9.89 182	10	13	
48	9.79 699	16	9.90 526	25	0.09 473	9.89 172	10	12	
49	9.79 715	15	9.90 552	26	0.09 447	9.89 162	10	11	
50	9.79 730	15	9.90 578	26	0.09 421	9.89 152	10	10	
51	9.79 746	16	9.90 604	26	0.09 395	9.89 142	10	9	
52	9.79 762	15	9.90 630	25	0.09 370	9.89 132	10	8	
53	9.79 777	15	9.90 656	26	0.09 344	9.89 121	10	7	
54	9.79 793	16	9.90 682	26	0.09 318	9.89 111	10	6	
55	9.79 809	15	9.90 707	25	0.09 292	9.89 101	10	5	
56	9.79 824	15	9.90 733	26	0.09 266	9.89 091	10	4	
57	9.79 840	16	9.90 759	26	0.09 240	9.89 081	10	3	
58	9.79 856	15	9.90 785	26	0.09 214	9.89 070	10	2	
59	9.79 871	15	9.90 811	25	0.09 189	9.89 060	10	1	
60	9.79 887	15	9.90 837	26	0.09 163	9.89 050	10	0	
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

P. P.			
	26	25	
6	2.6	2.5	
7	3.0	3.0	
8	3.4	3.4	
9	3.9	3.8	
10	4.3	4.2	
20	8.6	8.5	
30	13.0	12.7	
40	17.3	17.0	
50	21.6	21.2	

P. P.			
	16	16	15
6	1.6	1.6	1.5
7	1.9	1.8	1.8
8	2.2	2.1	2.0
9	2.5	2.4	2.3
10	2.7	2.6	2.6
20	5.5	5.3	5.1
30	8.2	8.0	7.7
40	11.0	10.6	10.3
50	13.7	13.3	12.9

P. P.			
	10	10	9
6	1.0	1.0	0.9
7	1.2	1.1	1.1
8	1.4	1.3	1.2
9	1.6	1.5	1.4
10	1.7	1.6	1.6
20	3.5	3.3	3.1
30	5.2	5.0	4.7
40	7.0	6.6	6.3
50	8.7	8.3	7.9

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	′
0	9.79 887	16	9.90 837	26	0.09 163	9.89 050	10	60
1	9.79 903	15	9.90 863	25	0.09 137	9.89 040	10	59
2	9.79 918	15	9.90 888	26	0.09 111	9.89 030	10	58
3	9.79 934	15	9.90 914	25	0.09 085	9.89 019	10	57
4	9.79 949	15	9.90 940	26	0.09 060	9.89 009	10	56
5	9.79 965	15	9.90 966	26	0.09 034	9.88 999	10	55
6	9.79 980	15	9.90 992	25	0.09 008	9.88 989	10	54
7	9.79 996	15	9.91 017	26	0.08 982	9.88 978	10	53
8	9.80 011	15	9.91 043	26	0.08 956	9.88 968	10	52
9	9.80 027	15	9.91 069	26	0.08 930	9.88 958	10	51
10	9.80 042	15	9.91 095	25	0.08 905	9.88 947	10	50
11	9.80 058	15	9.91 121	26	0.08 879	9.88 937	10	49
12	9.80 073	15	9.91 146	25	0.08 853	9.88 927	10	48
13	9.80 089	15	9.91 172	26	0.08 827	9.88 917	10	47
14	9.80 104	15	9.91 198	25	0.08 802	9.88 906	10	46
15	9.80 120	15	9.91 224	26	0.08 776	9.88 896	10	45
16	9.80 135	15	9.91 250	26	0.08 750	9.88 886	10	44
17	9.80 151	15	9.91 275	25	0.08 724	9.88 875	10	43
18	9.80 166	15	9.91 301	26	0.08 698	9.88 865	10	42
19	9.80 182	15	9.91 327	26	0.08 673	9.88 855	10	41
20	9.80 197	15	9.91 353	25	0.08 647	9.88 844	10	40
21	9.80 213	15	9.91 378	26	0.08 621	9.88 834	10	39
22	9.80 228	15	9.91 404	25	0.08 595	9.88 823	10	38
23	9.80 243	15	9.91 430	26	0.08 570	9.88 813	10	37
24	9.80 259	15	9.91 456	26	0.08 544	9.88 803	10	36
25	9.80 274	15	9.91 481	25	0.08 518	9.88 792	10	35
26	9.80 289	15	9.91 507	26	0.08 492	9.88 782	10	34
27	9.80 305	15	9.91 533	26	0.08 467	9.88 772	10	33
28	9.80 320	15	9.91 559	25	0.08 441	9.88 761	10	32
29	9.80 335	15	9.91 584	26	0.08 415	9.88 751	10	31
30	9.80 351	15	9.91 610	26	0.08 389	9.88 740	10	30
31	9.80 366	15	9.91 636	25	0.08 364	9.88 730	10	29
32	9.80 381	15	9.91 662	26	0.08 338	9.88 720	10	28
33	9.80 397	15	9.91 687	25	0.08 312	9.88 709	10	27
34	9.80 412	15	9.91 713	26	0.08 286	9.88 699	10	26
35	9.80 427	15	9.91 739	25	0.08 261	9.88 688	10	25
36	9.80 443	15	9.91 765	26	0.08 235	9.88 678	10	24
37	9.80 458	15	9.91 790	25	0.08 209	9.88 667	10	23
38	9.80 473	15	9.91 816	26	0.08 183	9.88 657	10	22
39	9.80 488	15	9.91 842	25	0.08 158	9.88 646	10	21
40	9.80 504	15	9.91 867	25	0.08 132	9.88 636	10	20
41	9.80 519	15	9.91 893	26	0.08 106	9.88 625	10	19
42	9.80 534	15	9.91 919	25	0.08 081	9.88 615	10	18
43	9.80 549	15	9.91 945	26	0.08 055	9.88 604	10	17
44	9.80 564	15	9.91 970	25	0.08 029	9.88 594	10	16
45	9.80 580	15	9.91 996	25	0.08 004	9.88 583	10	15
46	9.80 595	15	9.92 022	26	0.07 978	9.88 573	10	14
47	9.80 610	15	9.92 047	25	0.07 952	9.88 562	10	13
48	9.80 625	15	9.92 073	26	0.07 926	9.88 552	10	12
49	9.80 640	15	9.92 099	26	0.07 901	9.88 541	10	11
50	9.80 655	15	9.92 124	25	0.07 875	9.88 531	10	10
51	9.80 671	15	9.92 150	26	0.07 849	9.88 520	10	9
52	9.80 686	15	9.92 176	26	0.07 824	9.88 510	10	8
53	9.80 701	15	9.92 201	25	0.07 798	9.88 499	10	7
54	9.80 716	15	9.92 227	26	0.07 772	9.88 489	10	6
55	9.80 731	15	9.92 253	25	0.07 747	9.88 478	10	5
56	9.80 746	15	9.92 278	25	0.07 721	9.88 467	11	4
57	9.80 761	15	9.92 304	26	0.07 695	9.88 457	10	3
58	9.80 776	15	9.92 330	25	0.07 670	9.88 446	10	2
59	9.80 791	15	9.92 355	25	0.07 644	9.88 436	10	1
60	9.80 806	15	9.92 381	26	0.07 618	9.88 425	10	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	26	25	
6	2.6	2.5	
7	3.0	3.0	
8	3.4	3.4	
9	3.9	3.8	
10	4.3	4.2	
20	8.6	8.5	
30	13.0	12.7	
40	17.3	17.0	
50	21.6	21.2	

P. P.

	16	15	15
6	1.6	1.5	1.5
7	1.8	1.8	1.7
8	2.1	2.0	2.0
9	2.4	2.3	2.2
10	2.6	2.6	2.5
20	5.3	5.1	5.0
30	8.0	7.7	7.5
40	10.6	10.3	10.0
50	13.3	12.9	12.5

P. P.

	11	10	10
6	1.1	1.0	1.0
7	1.3	1.2	1.1
8	1.4	1.4	1.3
9	1.6	1.6	1.5
10	1.8	1.7	1.6
20	3.6	3.5	3.3
30	5.5	5.2	5.0
40	7.3	7.0	6.6
50	9.1	8.7	8.3

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9.80 806	15	9.92 381	25	0.07 618	9.88 425	10	60	
1	9.80 822	15	9.92 407	25	0.07 593	9.88 415	11	59	
2	9.80 837	15	9.92 432	26	0.07 567	9.88 404	10	58	
3	9.80 852	15	9.92 458	25	0.07 541	9.88 393	10	57	
4	9.80 867	15	9.92 484	25	0.07 516	9.88 383	10	56	
5	9.80 882	15	9.92 509	25	0.07 490	9.88 372	11	55	
6	9.80 897	15	9.92 535	26	0.07 465	9.88 361	10	54	
7	9.80 912	15	9.92 561	25	0.07 439	9.88 351	10	53	
8	9.80 927	15	9.92 586	25	0.07 413	9.88 340	11	52	
9	9.80 942	15	9.92 612	26	0.07 388	9.88 329	10	51	
10	9.80 957	15	9.92 638	25	0.07 362	9.88 319	10	50	
11	9.80 972	15	9.92 663	25	0.07 336	9.88 308	11	49	
12	9.80 987	15	9.92 689	25	0.07 311	9.88 297	10	48	
13	9.81 001	14	9.92 714	26	0.07 285	9.88 287	10	47	
14	9.81 016	15	9.92 740	25	0.07 259	9.88 276	11	46	
15	9.81 031	15	9.92 766	25	0.07 234	9.88 265	10	45	
16	9.81 046	15	9.92 791	25	0.07 208	9.88 255	10	44	
17	9.81 061	15	9.92 817	25	0.07 183	9.88 244	11	43	
18	9.81 076	14	9.92 842	25	0.07 157	9.88 233	10	42	
19	9.81 091	15	9.92 868	26	0.07 131	9.88 223	11	41	
20	9.81 106	15	9.92 894	25	0.07 106	9.88 212	10	40	
21	9.81 121	15	9.92 919	25	0.07 080	9.88 201	11	39	
22	9.81 136	15	9.92 945	26	0.07 055	9.88 190	11	38	
23	9.81 150	14	9.92 971	25	0.07 029	9.88 180	10	37	
24	9.81 165	15	9.92 996	25	0.07 003	9.88 169	11	36	
25	9.81 180	15	9.93 022	25	0.06 978	9.88 158	10	35	
26	9.81 195	15	9.93 047	25	0.06 952	9.88 147	11	34	
27	9.81 210	15	9.93 073	25	0.06 927	9.88 137	10	33	
28	9.81 225	15	9.93 098	26	0.06 901	9.88 126	11	32	
29	9.81 239	14	9.93 124	25	0.06 875	9.88 115	10	31	
30	9.81 254	15	9.93 150	25	0.06 850	9.88 104	11	30	
31	9.81 269	15	9.93 175	25	0.06 824	9.88 094	10	29	
32	9.81 284	15	9.93 201	25	0.06 799	9.88 083	11	28	
33	9.81 299	15	9.93 226	25	0.06 773	9.88 072	11	27	
34	9.81 313	14	9.93 252	26	0.06 748	9.88 061	10	26	
35	9.81 328	15	9.93 278	25	0.06 722	9.88 050	11	25	
36	9.81 343	15	9.93 303	25	0.06 696	9.88 039	11	24	
37	9.81 358	15	9.93 329	25	0.06 671	9.88 029	10	23	
38	9.81 372	14	9.93 354	25	0.06 645	9.88 018	11	22	
39	9.81 387	15	9.93 380	26	0.06 620	9.88 007	11	21	
40	9.81 402	15	9.93 405	25	0.06 594	9.87 996	10	20	
41	9.81 416	14	9.93 431	25	0.06 569	9.87 985	11	19	
42	9.81 431	15	9.93 456	25	0.06 543	9.87 974	11	18	
43	9.81 446	15	9.93 482	26	0.06 518	9.87 963	11	17	
44	9.81 460	14	9.93 508	25	0.06 492	9.87 953	10	16	
45	9.81 475	15	9.93 533	25	0.06 466	9.87 942	11	15	
46	9.81 490	14	9.93 559	25	0.06 441	9.87 931	11	14	
47	9.81 504	15	9.93 584	25	0.06 415	9.87 920	11	13	
48	9.81 519	15	9.93 610	25	0.06 390	9.87 909	10	12	
49	9.81 534	14	9.93 635	25	0.06 364	9.87 898	11	11	
50	9.81 548	14	9.93 661	25	0.06 339	9.87 887	11	10	
51	9.81 563	15	9.93 686	25	0.06 313	9.87 876	11	9	
52	9.81 578	14	9.93 712	26	0.06 288	9.87 865	11	8	
53	9.81 592	14	9.93 737	25	0.06 262	9.87 854	11	7	
54	9.81 607	15	9.93 763	25	0.06 237	9.87 844	10	6	
55	9.81 621	14	9.93 788	25	0.06 211	9.87 833	11	5	
56	9.81 636	15	9.93 814	26	0.06 186	9.87 822	11	4	
57	9.81 650	14	9.93 840	25	0.06 160	9.87 811	11	3	
58	9.81 665	15	9.93 865	25	0.06 134	9.87 800	11	2	
59	9.81 680	15	9.93 891	25	0.06 109	9.87 789	11	1	
60	9.81 694	14	9.93 916	25	0.06 083	9.87 778	11	0	
′	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

	26	25
6	2.6	2.5
7	3.0	3.0
8	3.4	3.4
9	3.9	3.8
10	4.3	4.2
20	8.6	8.5
30	13.0	12.7
40	17.3	17.0
50	21.6	21.2

	15	15	14
6	1.5	1.5	1.4
7	1.8	1.7	1.7
8	2.0	2.0	1.9
9	2.3	2.2	2.2
10	2.6	2.5	2.4
20	5.1	5.0	4.8
30	7.7	7.5	7.2
40	10.3	10.0	9.6
50	12.9	12.5	12.1

	11	10
6	1.1	1.0
7	1.3	1.2
8	1.4	1.4
9	1.6	1.6
10	1.8	1.7
20	3.6	3.5
30	5.5	5.2
40	7.3	7.0
50	9.1	8.7

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.	
0	9.81 694	14	9.93 916	25	0.06 083	9.87 778	11	60
1	9.81 709	14	9.93 942	25	0.06 058	9.87 767	11	59
2	9.81 723	14	9.93 967	25	0.06 032	9.87 756	11	58
3	9.81 738	14	9.93 993	25	0.06 007	9.87 745	11	57
4	9.81 752	14	9.94 018	25	0.05 981	9.87 734	11	56
5	9.81 767	14	9.94 044	25	0.05 956	9.87 723	11	55
6	9.81 781	14	9.94 069	25	0.05 930	9.87 712	11	54
7	9.81 796	14	9.94 095	25	0.05 905	9.87 701	11	53
8	9.81 810	14	9.94 120	25	0.05 879	9.87 690	11	52
9	9.81 824	14	9.94 146	25	0.05 854	9.87 679	11	51
10	9.81 839	14	9.94 171	25	0.05 828	9.87 668	11	50
11	9.81 853	14	9.94 197	25	0.05 803	9.87 657	11	49
12	9.81 868	14	9.94 222	25	0.05 777	9.87 645	11	48
13	9.81 882	14	9.94 248	25	0.05 752	9.87 634	11	47
14	9.81 897	14	9.94 273	25	0.05 726	9.87 623	11	46
15	9.81 911	14	9.94 299	25	0.05 701	9.87 612	11	45
16	9.81 925	14	9.94 324	25	0.05 675	9.87 601	11	44
17	9.81 940	14	9.94 350	25	0.05 650	9.87 590	11	43
18	9.81 954	14	9.94 375	25	0.05 625	9.87 579	11	42
19	9.81 969	14	9.94 400	25	0.05 599	9.87 568	11	41
20	9.81 983	14	9.94 426	25	0.05 574	9.87 557	11	40
21	9.81 997	14	9.94 451	25	0.05 548	9.87 546	11	39
22	9.82 012	14	9.94 477	25	0.05 523	9.87 535	11	38
23	9.82 026	14	9.94 502	25	0.05 497	9.87 523	11	37
24	9.82 040	14	9.94 528	25	0.05 472	9.87 512	11	36
25	9.82 055	14	9.94 553	25	0.05 446	9.87 501	11	35
26	9.82 069	14	9.94 579	25	0.05 421	9.87 490	11	34
27	9.82 083	14	9.94 604	25	0.05 395	9.87 479	11	33
28	9.82 098	14	9.94 630	25	0.05 370	9.87 468	11	32
29	9.82 112	14	9.94 655	25	0.05 344	9.87 457	11	31
30	9.82 126	14	9.94 681	25	0.05 319	9.87 445	11	30
31	9.82 140	14	9.94 706	25	0.05 293	9.87 434	11	29
32	9.82 155	14	9.94 732	25	0.05 268	9.87 423	11	28
33	9.82 169	14	9.94 757	25	0.05 243	9.87 412	11	27
34	9.82 183	14	9.94 782	25	0.05 217	9.87 401	11	26
35	9.82 197	14	9.94 808	25	0.05 192	9.87 389	11	25
36	9.82 212	14	9.94 833	25	0.05 166	9.87 378	11	24
37	9.82 226	14	9.94 859	25	0.05 141	9.87 367	11	23
38	9.82 240	14	9.94 884	25	0.05 115	9.87 356	11	22
39	9.82 254	14	9.94 910	25	0.05 090	9.87 345	11	21
40	9.82 269	14	9.94 935	25	0.05 064	9.87 333	11	20
41	9.82 283	14	9.94 961	25	0.05 039	9.87 322	11	19
42	9.82 297	14	9.94 986	25	0.05 014	9.87 311	11	18
43	9.82 311	14	9.95 011	25	0.04 988	9.87 300	11	17
44	9.82 325	14	9.95 037	25	0.04 963	9.87 288	11	16
45	9.82 339	14	9.95 062	25	0.04 937	9.87 277	11	15
46	9.82 354	14	9.95 088	25	0.04 912	9.87 266	11	14
47	9.82 368	14	9.95 113	25	0.04 886	9.87 254	11	13
48	9.82 382	14	9.95 139	25	0.04 861	9.87 243	11	12
49	9.82 396	14	9.95 164	25	0.04 836	9.87 232	11	11
50	9.82 410	14	9.95 189	25	0.04 810	9.87 221	11	10
51	9.82 424	14	9.95 215	25	0.04 785	9.87 209	11	9
52	9.82 438	14	9.95 240	25	0.04 759	9.87 198	11	8
53	9.82 452	14	9.95 266	25	0.04 734	9.87 187	11	7
54	9.82 467	14	9.95 291	25	0.04 708	9.87 175	11	6
55	9.82 481	14	9.95 316	25	0.04 683	9.87 164	11	5
56	9.82 495	14	9.95 342	25	0.04 658	9.87 153	11	4
57	9.82 509	14	9.95 367	25	0.04 632	9.87 141	11	3
58	9.82 523	14	9.95 393	25	0.04 607	9.87 130	11	2
59	9.82 537	14	9.95 418	25	0.04 581	9.87 118	11	1
60	9.82 551	14	9.95 443	25	0.04 556	9.87 107	11	0
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′

P. P.

	25		25
6	2.5		2.5
7	3.0		2.9
8	3.4		3.3
9	3.8		3.7
10	4.2		4.1
20	8.5		8.3
30	12.7		12.5
40	17.0		16.6
50	21.2		20.8

	14	14
6	1.4	1.4
7	1.7	1.6
8	1.9	1.8
9	2.2	2.1
10	2.4	2.3
20	4.8	4.6
30	7.2	7.0
40	9.6	9.3
50	12.1	11.6

	11	11
6	1.1	1.1
7	1.3	1.3
8	1.5	1.4
9	1.7	1.6
10	1.9	1.8
20	3.8	3.6
30	5.7	5.5
40	7.6	7.3
50	9.6	9.1

P. P.

	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9.82 551	14	9.95 443	25	0.04 556	9.87 107	11	60	
1	9.82 565	14	9.95 469	25	0.04 531	9.87 096	11	59	
2	9.82 579	14	9.95 494	25	0.04 505	9.87 084	11	58	
3	9.82 593	14	9.95 520	25	0.04 480	9.87 073	11	57	
4	9.82 607	14	9.95 545	25	0.04 454	9.87 062	11	56	
5	9.82 621	14	9.95 571	25	0.04 429	9.87 050	11	55	
6	9.82 635	14	9.95 596	25	0.04 404	9.87 039	11	54	
7	9.82 649	14	9.95 621	25	0.04 378	9.87 027	11	53	
8	9.82 663	14	9.95 647	25	0.04 353	9.87 016	11	52	
9	9.82 677	14	9.95 672	25	0.04 327	9.87 004	11	51	
10	9.82 691	14	9.95 697	25	0.04 302	9.86 993	11	50	
11	9.82 705	14	9.95 723	25	0.04 277	9.86 982	11	49	
12	9.82 719	14	9.95 748	25	0.04 251	9.86 970	11	48	
13	9.82 733	14	9.95 774	25	0.04 226	9.86 959	11	47	
14	9.82 746	13	9.95 799	25	0.04 200	9.86 947	11	46	
15	9.82 760	14	9.95 824	25	0.04 175	9.86 936	11	45	
16	9.82 774	14	9.95 850	25	0.04 150	9.86 924	11	44	
17	9.82 788	14	9.95 875	25	0.04 124	9.86 913	11	43	
18	9.82 802	13	9.95 901	25	0.04 099	9.86 901	11	42	
19	9.82 816	14	9.95 926	25	0.04 074	9.86 890	11	41	
20	9.82 830	14	9.95 951	25	0.04 048	9.86 878	11	40	
21	9.82 844	14	9.95 977	25	0.04 023	9.86 867	11	39	
22	9.82 858	14	9.96 002	25	0.03 997	9.86 855	11	38	
23	9.82 871	13	9.96 027	25	0.03 972	9.86 844	11	37	
24	9.82 885	14	9.96 053	25	0.03 947	9.86 832	11	36	
25	9.82 899	14	9.96 078	25	0.03 921	9.86 821	11	35	
26	9.82 913	14	9.96 104	25	0.03 896	9.86 809	11	34	
27	9.82 927	14	9.96 129	25	0.03 871	9.86 798	12	33	
28	9.82 940	13	9.96 154	25	0.03 845	9.86 786	11	32	
29	9.82 954	14	9.96 180	25	0.03 820	9.86 774	11	31	
30	9.82 968	14	9.96 205	25	0.03 795	9.86 763	11	30	
31	9.82 982	14	9.96 230	25	0.03 769	9.86 751	11	29	
32	9.82 996	14	9.96 256	25	0.03 744	9.86 740	11	28	
33	9.83 009	13	9.96 281	25	0.03 718	9.86 728	12	27	
34	9.83 023	14	9.96 306	25	0.03 693	9.86 716	11	26	
35	9.83 037	14	9.96 332	25	0.03 668	9.86 705	11	25	
36	9.83 051	14	9.96 357	25	0.03 642	9.86 693	11	24	
37	9.83 064	13	9.96 383	25	0.03 617	9.86 682	11	23	
38	9.83 078	14	9.96 408	25	0.03 592	9.86 670	12	22	
39	9.83 092	14	9.96 433	25	0.03 566	9.86 658	11	21	
40	9.83 106	13	9.96 459	25	0.03 541	9.86 647	11	20	
41	9.83 119	14	9.96 484	25	0.03 516	9.86 635	12	19	
42	9.83 133	14	9.96 509	25	0.03 490	9.86 623	11	18	
43	9.83 147	14	9.96 535	25	0.03 465	9.86 612	11	17	
44	9.83 160	13	9.96 560	25	0.03 440	9.86 600	12	16	
45	9.83 174	14	9.96 585	25	0.03 414	9.86 588	11	15	
46	9.83 188	14	9.96 611	25	0.03 389	9.86 577	11	14	
47	9.83 201	13	9.96 636	25	0.03 364	9.86 565	12	13	
48	9.83 215	14	9.96 661	25	0.03 338	9.86 553	12	12	
49	9.83 229	14	9.96 687	25	0.03 313	9.86 542	11	11	
50	9.83 242	13	9.96 712	25	0.03 287	9.86 530	12	10	
51	9.83 256	13	9.96 737	25	0.03 262	9.86 518	11	9	
52	9.83 269	13	9.96 763	25	0.03 237	9.86 507	12	8	
53	9.83 283	14	9.96 788	25	0.03 211	9.86 495	12	7	
54	9.83 297	13	9.96 813	25	0.03 186	9.86 483	12	6	
55	9.83 310	13	9.96 839	25	0.03 161	9.86 471	12	5	
56	9.83 324	13	9.96 864	25	0.03 135	9.86 460	12	4	
57	9.83 337	13	9.96 889	25	0.03 110	9.86 448	11	3	
58	9.83 351	13	9.96 915	25	0.03 085	9.86 436	12	2	
59	9.83 365	14	9.96 940	25	0.03 059	9.86 424	12	1	
60	9.83 378	13	9.96 965	25	0.03 034	9.86 412	12	0	
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

P. P.			
	25	25	
6	2.5	2.5	
7	3.0	2.9	
8	3.4	3.3	
9	3.8	3.7	
10	4.2	4.1	
20	8.5	8.3	
30	12.7	12.5	
40	17.0	16.6	
50	21.2	20.8	

P. P.			
	14	13	
6	1.4	1.3	
7	1.6	1.6	
8	1.8	1.8	
9	2.1	2.0	
10	2.3	2.2	
20	4.6	4.5	
30	7.0	6.7	
40	9.3	9.0	
50	11.6	11.2	

P. P.			
	12	11	11
6	1.2	1.1	1.1
7	1.4	1.3	1.3
8	1.6	1.5	1.4
9	1.8	1.7	1.6
10	2.0	1.9	1.8
20	4.0	3.8	3.6
30	6.0	5.7	5.5
40	8.0	7.6	7.3
50	10.0	9.6	9.1

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9.83 378	13	9.96 965	25	0.03 034	9.86 412	11	60	
1	9.83 392	13	9.96 991	25	0.03 009	9.86 401	12	59	
2	9.83 405	13	9.97 016	25	0.02 984	9.86 389	11	58	
3	9.83 419	13	9.97 041	25	0.02 958	9.86 377	12	57	
4	9.83 432	13	9.97 067	25	0.02 933	9.86 365	12	56	
5	9.83 446	13	9.97 092	25	0.02 908	9.86 354	11	55	
6	9.83 459	13	9.97 117	25	0.02 882	9.86 342	12	54	
7	9.83 473	13	9.97 143	25	0.02 857	9.86 330	11	53	
8	9.83 486	13	9.97 168	25	0.02 832	9.86 318	12	52	
9	9.83 500	13	9.97 193	25	0.02 806	9.86 306	12	51	25 25
10	9.83 513	13	9.97 219	25	0.02 781	9.86 294	12	50	6 2.5 2.5
11	9.83 527	13	9.97 244	25	0.02 756	9.86 282	11	49	7 3.0 2.9
12	9.83 540	13	9.97 269	25	0.02 730	9.86 271	12	48	8 3.4 3.3
13	9.83 554	13	9.97 295	25	0.02 705	9.86 259	12	47	9 3.8 3.7
14	9.83 567	13	9.97 320	25	0.02 680	9.86 247	12	46	10 4.2 4.1
15	9.83 580	13	9.97 345	25	0.02 654	9.86 235	11	45	20 8.5 8.3
16	9.83 594	13	9.97 370	25	0.02 629	9.86 223	12	44	30 12.7 12.5
17	9.83 607	13	9.97 396	25	0.02 604	9.86 211	12	43	40 17.0 16.6
18	9.83 621	13	9.97 421	25	0.02 578	9.86 199	12	42	50 21.2 20.8
19	9.83 634	13	9.97 446	25	0.02 553	9.86 187	12	41	
20	9.83 647	13	9.97 472	25	0.02 528	9.86 176	11	40	
21	9.83 661	13	9.97 497	25	0.02 502	9.86 164	12	39	
22	9.83 674	13	9.97 522	25	0.02 477	9.86 152	12	38	
23	9.83 688	13	9.97 548	25	0.02 452	9.86 140	12	37	
24	9.83 701	13	9.97 573	25	0.02 427	9.86 128	12	36	
25	9.83 714	13	9.97 598	25	0.02 401	9.86 116	12	35	
26	9.83 728	13	9.97 624	25	0.02 376	9.86 104	12	34	13 13
27	9.83 741	13	9.97 649	25	0.02 351	9.86 092	12	33	6 1.3 1.3
28	9.83 754	13	9.97 674	25	0.02 325	9.86 080	12	32	7 1.6 1.5
29	9.83 768	13	9.97 699	25	0.02 300	9.86 068	12	31	8 1.8 1.7
30	9.83 781	13	9.97 725	25	0.02 275	9.86 056	12	30	9 2.0 1.9
31	9.83 794	13	9.97 750	25	0.02 249	9.86 044	12	29	10 2.2 2.1
32	9.83 808	13	9.97 775	25	0.02 224	9.86 032	12	28	20 4.5 4.3
33	9.83 821	13	9.97 801	25	0.02 199	9.86 020	12	27	30 6.7 6.5
34	9.83 834	13	9.97 826	25	0.02 174	9.86 008	12	26	40 9.0 8.6
35	9.83 847	13	9.97 851	25	0.02 148	9.85 996	12	25	50 11.2 10.8
36	9.83 861	13	9.97 877	25	0.02 123	9.85 984	12	24	
37	9.83 874	13	9.97 902	25	0.02 098	9.85 972	12	23	
38	9.83 887	13	9.97 927	25	0.02 072	9.85 960	12	22	
39	9.83 900	13	9.97 952	25	0.02 047	9.85 948	12	21	
40	9.83 914	13	9.97 978	25	0.02 022	9.85 936	12	20	
41	9.83 927	13	9.98 003	25	0.01 996	9.85 924	12	19	
42	9.83 940	13	9.98 028	25	0.01 971	9.85 912	12	18	
43	9.83 953	13	9.98 054	25	0.01 946	9.85 900	12	17	
44	9.83 967	13	9.98 079	25	0.01 921	9.85 887	12	16	12 12 11
45	9.83 980	13	9.98 104	25	0.01 895	9.85 875	12	15	6 1.2 1.2 1.1
46	9.83 993	13	9.98 129	25	0.01 870	9.85 863	12	14	7 1.4 1.4 1.3
47	9.84 006	13	9.98 155	25	0.01 845	9.85 851	12	13	8 1.6 1.6 1.5
48	9.84 019	13	9.98 180	25	0.01 819	9.85 839	12	12	9 1.9 1.8 1.7
49	9.84 033	13	9.98 205	25	0.01 794	9.85 827	12	11	10 2.1 2.0 1.9
50	9.84 046	13	9.98 231	25	0.01 769	9.85 815	12	10	20 4.1 4.0 3.8
51	9.84 059	13	9.98 256	25	0.01 744	9.85 803	12	9	30 6.2 6.0 5.7
52	9.84 072	13	9.98 281	25	0.01 718	9.85 791	12	8	40 8.3 8.0 7.6
53	9.84 085	13	9.98 306	25	0.01 693	9.85 778	12	7	50 10.4 10.0 9.6
54	9.84 098	13	9.98 332	25	0.01 668	9.85 766	12	6	
55	9.84 111	13	9.98 357	25	0.01 642	9.85 754	12	5	
56	9.84 124	13	9.98 382	25	0.01 617	9.85 742	12	4	
57	9.84 138	13	9.98 408	25	0.01 592	9.85 730	12	3	
58	9.84 151	13	9.98 433	25	0.01 567	9.85 718	12	2	
59	9.84 164	13	9.98 458	25	0.01 541	9.85 705	12	1	
60	9.84 177	13	9.98 483	25	0.01 516	9.85 693	12	0	
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

′	Log. Sin.	d.	Log. Tan.	c. d.	Log. Cot.	Log. Cos.	d.		P. P.
0	9.84 177	13	9.98 483	25	0.01 516	9.85 693	12	60	
1	9.84 190	13	9.98 509	25	0.01 491	9.85 681	12	59	
2	9.84 203	13	9.98 534	25	0.01 465	9.85 669	12	58	
3	9.84 216	13	9.98 559	25	0.01 440	9.85 657	12	57	
4	9.84 229	13	9.98 585	25	0.01 415	9.85 644	12	56	
5	9.84 242	13	9.98 610	25	0.01 390	9.85 632	12	55	
6	9.84 255	13	9.98 635	25	0.01 364	9.85 620	12	54	
7	9.84 268	13	9.98 660	25	0.01 339	9.85 608	12	53	
8	9.84 281	13	9.98 686	25	0.01 314	9.85 595	12	52	
9	9.84 294	13	9.98 711	25	0.01 289	9.85 583	12	51	25 25
10	9.84 307	13	9.98 736	25	0.01 263	9.85 571	12	50	6 2.5 2.5
11	9.84 320	13	9.98 762	25	0.01 238	9.85 559	12	49	7 3.0 2.9
12	9.84 333	13	9.98 787	25	0.01 213	9.85 546	12	48	8 3.4 3.3
13	9.84 346	13	9.98 812	25	0.01 187	9.85 534	12	47	9 3.8 3.7
14	9.84 359	13	9.98 837	25	0.01 162	9.85 522	12	46	10 4.2 4.1
15	9.84 372	13	9.98 863	25	0.01 137	9.85 509	12	45	20 8.5 8.3
16	9.84 385	13	9.98 888	25	0.01 112	9.85 497	12	44	30 12.7 12.5
17	9.84 398	13	9.98 913	25	0.01 086	9.85 485	12	43	40 17.0 16.6
18	9.84 411	13	9.98 938	25	0.01 061	9.85 472	12	42	50 21.2 20.8
19	9.84 424	13	9.98 964	25	0.01 036	9.85 460	12	41	
20	9.84 437	13	9.98 989	25	0.01 010	9.85 448	12	40	
21	9.84 450	13	9.99 014	25	0.00 985	9.85 435	12	39	
22	9.84 463	13	9.99 040	25	0.00 960	9.85 423	12	38	
23	9.84 476	13	9.99 065	25	0.00 935	9.85 411	12	37	
24	9.84 489	13	9.99 090	25	0.00 909	9.85 398	12	36	
25	9.84 502	12	9.99 115	25	0.00 884	9.85 386	12	35	
26	9.84 514	13	9.99 141	25	0.00 859	9.85 374	12	34	
27	9.84 527	13	9.99 166	25	0.00 834	9.85 361	12	33	13 13
28	9.84 540	13	9.99 191	25	0.00 808	9.85 349	12	32	6 1.3 1.3
29	9.84 553	13	9.99 216	25	0.00 783	9.85 336	12	31	7 1.6 1.5
30	9.84 566	13	9.99 242	25	0.00 758	9.85 324	12	30	8 1.8 1.7
31	9.84 579	13	9.99 267	25	0.00 733	9.85 312	12	29	9 2.0 1.9
32	9.84 592	12	9.99 292	25	0.00 707	9.85 299	12	28	10 2.2 2.1
33	9.84 604	13	9.99 318	25	0.00 682	9.85 287	12	27	20 4.5 4.3
34	9.84 617	13	9.99 343	25	0.00 657	9.85 274	12	26	30 6.7 6.5
35	9.84 630	13	9.99 368	25	0.00 631	9.85 262	12	25	40 9.0 8.6
36	9.84 643	13	9.99 393	25	0.00 606	9.85 249	12	24	50 11.2 10.8
37	9.84 656	13	9.99 419	25	0.00 581	9.85 237	12	23	
38	9.84 669	13	9.99 444	25	0.00 556	9.85 224	12	22	
39	9.84 681	12	9.99 469	25	0.00 530	9.85 212	12	21	
40	9.84 694	13	9.99 494	25	0.00 505	9.85 199	12	20	
41	9.84 707	12	9.99 520	25	0.00 480	9.85 187	12	19	
42	9.84 720	13	9.99 545	25	0.00 455	9.85 174	12	18	
43	9.84 732	13	9.99 570	25	0.00 429	9.85 162	12	17	
44	9.84 745	13	9.99 595	25	0.00 404	9.85 149	12	16	12 12
45	9.84 758	12	9.99 621	25	0.00 379	9.85 137	12	15	6 1.2 1.2
46	9.84 771	13	9.99 646	25	0.00 353	9.85 124	12	14	7 1.4 1.4
47	9.84 783	12	9.99 671	25	0.00 328	9.85 112	12	13	8 1.6 1.6
48	9.84 796	13	9.99 697	25	0.00 303	9.85 099	12	12	9 1.9 1.8
49	9.84 809	12	9.99 722	25	0.00 278	9.85 087	12	11	10 2.1 2.0
50	9.84 822	13	9.99 747	25	0.00 252	9.85 074	12	10	20 4.2 4.0
51	9.84 834	12	9.99 772	25	0.00 227	9.85 062	12	9	30 6.2 6.0
52	9.84 847	13	9.99 798	25	0.00 202	9.85 049	12	8	40 8.3 8.0
53	9.84 860	12	9.99 823	25	0.00 177	9.85 037	13	7	50 10.4 10.0
54	9.84 872	12	9.99 848	25	0.00 151	9.85 024	13	6	
55	9.84 885	13	9.99 873	25	0.00 126	9.85 011	12	5	
56	9.84 898	13	9.99 899	25	0.00 101	9.84 999	12	4	
57	9.84 910	12	9.99 924	25	0.00 076	9.84 986	12	3	
58	9.84 923	13	9.99 949	25	0.00 050	9.84 974	13	2	
59	9.84 936	13	9.99 974	25	0.00 025	9.84 961	13	1	
60	9.84 948	12	0.00 000	25	0.00 000	9.84 948	12	0	
	Log. Cos.	d.	Log. Cot.	c. d.	Log. Tan.	Log. Sin.	d.	′	P. P.

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	0°				1°			
	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.
0	.00000	One	.00000	Infinite	.01745	.99985	.01746	57.2900
1	.00029	One	.00029	3437.75	.01774	.99984	.01775	56.3506
2	.00058	One	.00058	1718.87	.01803	.99984	.01804	55.4415
3	.00087	One	.00087	1145.92	.01832	.99983	.01833	54.5613
4	.00116	One	.00116	859.436	.01862	.99983	.01862	53.7086
5	.00145	One	.00145	687.549	.01891	.99982	.01891	52.8821
6	.00175	One	.00175	572.957	.01920	.99982	.01920	52.0807
7	.00204	One	.00204	491.106	.01949	.99981	.01949	51.3032
8	.00233	One	.00233	429.718	.01978	.99980	.01978	50.5485
9	.00262	One	.00262	381.971	.02007	.99980	.02007	49.8157
10	.00291	One	.00291	343.774	.02036	.99979	.02036	49.1039
11	.00320	.99999	.00320	312.521	.02065	.99979	.02066	48.4121
12	.00349	.99999	.00349	286.478	.02094	.99978	.02095	47.7395
13	.00378	.99999	.00378	264.441	.02123	.99977	.02124	47.0853
14	.00407	.99999	.00407	245.552	.02152	.99977	.02153	46.4489
15	.00436	.99999	.00436	229.182	.02181	.99976	.02182	45.8294
16	.00465	.99999	.00465	214.858	.02211	.99976	.02211	45.2261
17	.00495	.99999	.00495	202.219	.02240	.99975	.02240	44.6386
18	.00524	.99999	.00524	190.984	.02269	.99974	.02269	44.0661
19	.00553	.99998	.00553	180.932	.02298	.99974	.02298	43.5081
20	.00582	.99998	.00582	171.885	.02327	.99973	.02328	42.9641
21	.00611	.99998	.00611	163.700	.02356	.99972	.02357	42.4335
22	.00640	.99998	.00640	156.259	.02385	.99972	.02386	41.9158
23	.00669	.99998	.00669	149.465	.02414	.99971	.02415	41.4106
24	.00698	.99998	.00698	143.237	.02443	.99970	.02444	40.9174
25	.00727	.99997	.00727	137.507	.02472	.99969	.02473	40.4358
26	.00756	.99997	.00756	132.219	.02501	.99969	.02502	39.9655
27	.00785	.99997	.00785	127.321	.02530	.99968	.02531	39.5059
28	.00814	.99997	.00815	122.774	.02560	.99967	.02560	39.0568
29	.00844	.99996	.00844	118.540	.02589	.99966	.02589	38.6177
30	.00873	.99996	.00873	114.589	.02618	.99966	.02619	38.1885
31	.00902	.99996	.00902	110.892	.02647	.99965	.02648	37.7686
32	.00931	.99996	.00931	107.426	.02676	.99964	.02677	37.3579
33	.00960	.99995	.00960	104.171	.02705	.99963	.02706	36.9560
34	.00989	.99995	.00989	101.107	.02734	.99963	.02735	36.5627
35	.01018	.99995	.01018	98.2179	.02763	.99962	.02764	36.1776
36	.01047	.99995	.01047	95.4895	.02792	.99961	.02793	35.8006
37	.01076	.99994	.01076	92.9085	.02821	.99960	.02822	35.4313
38	.01105	.99994	.01105	90.4633	.02850	.99959	.02851	35.0695
39	.01134	.99994	.01135	88.1436	.02879	.99959	.02881	34.7151
40	.01164	.99993	.01164	85.9398	.02908	.99958	.02910	34.3678
41	.01193	.99993	.01193	83.8435	.02938	.99957	.02939	34.0273
42	.01222	.99993	.01222	81.8470	.02967	.99956	.02968	33.6935
43	.01251	.99992	.01251	79.9434	.02996	.99955	.02997	33.3662
44	.01280	.99992	.01280	78.1263	.03025	.99954	.03026	33.0452
45	.01309	.99991	.01309	76.3900	.03054	.99953	.03055	32.7303
46	.01338	.99991	.01338	74.7292	.03083	.99952	.03084	32.4213
47	.01367	.99991	.01367	73.1390	.03112	.99952	.03114	32.1181
48	.01396	.99990	.01396	71.6151	.03141	.99951	.03143	31.8205
49	.01425	.99990	.01425	70.1533	.03170	.99950	.03172	31.5284
50	.01454	.99989	.01455	68.7501	.03199	.99949	.03201	31.2416
51	.01483	.99989	.01484	67.4019	.03228	.99948	.03230	30.9599
52	.01513	.99989	.01513	66.1055	.03257	.99947	.03259	30.6833
53	.01542	.99988	.01542	64.8580	.03286	.99946	.03288	30.4116
54	.01571	.99988	.01571	63.6567	.03316	.99945	.03317	30.1446
55	.01600	.99987	.01600	62.4992	.03345	.99944	.03346	29.8823
56	.01629	.99987	.01629	61.3829	.03374	.99943	.03376	29.6245
57	.01658	.99986	.01658	60.3058	.03403	.99942	.03405	29.3711
58	.01687	.99986	.01687	59.2659	.03432	.99941	.03434	29.1220
59	.01716	.99985	.01716	58.2612	.03461	.99940	.03463	28.8771
60	.01745	.99985	.01746	57.2900	.03490	.99939	.03492	28.6363
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.

TABLE XIII. — NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	2°				3°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.03490	.99939	.03492	28.6363	.05234	.99863	.05241	19.0811	60
1	.03519	.99938	.03521	28.3994	.05263	.99861	.05270	18.9755	59
2	.03548	.99937	.03550	28.1664	.05292	.99860	.05299	18.8711	58
3	.03577	.99936	.03579	27.9372	.05321	.99858	.05328	18.7678	57
4	.03606	.99935	.03609	27.7117	.05350	.99857	.05357	18.6656	56
5	.03635	.99934	.03638	27.4899	.05379	.99855	.05387	18.5645	55
6	.03664	.99933	.03667	27.2715	.05408	.99854	.05416	18.4645	54
7	.03693	.99932	.03696	27.0566	.05437	.99852	.05445	18.3655	53
8	.03723	.99931	.03725	26.8450	.05466	.99851	.05474	18.2677	52
9	.03752	.99930	.03754	26.6367	.05495	.99849	.05503	18.1708	51
10	.03781	.99929	.03783	26.4316	.05524	.99847	.05533	18.0750	50
11	.03810	.99927	.03812	26.2296	.05553	.99846	.05562	17.9802	49
12	.03839	.99926	.03842	26.0307	.05582	.99844	.05591	17.8863	48
13	.03868	.99925	.03871	25.8348	.05611	.99842	.05620	17.7934	47
14	.03897	.99924	.03900	25.6418	.05640	.99841	.05649	17.7015	46
15	.03926	.99923	.03929	25.4517	.05669	.99839	.05678	17.6106	45
16	.03955	.99922	.03958	25.2644	.05698	.99838	.05708	17.5205	44
17	.03984	.99921	.03987	25.0798	.05727	.99836	.05737	17.4314	43
18	.04013	.99919	.04016	24.8978	.05756	.99834	.05766	17.3432	42
19	.04042	.99918	.04046	24.7185	.05785	.99833	.05795	17.2558	41
20	.04071	.99917	.04075	24.5418	.05814	.99831	.05824	17.1693	40
21	.04100	.99916	.04104	24.3675	.05844	.99829	.05854	17.0837	39
22	.04129	.99915	.04133	24.1957	.05873	.99827	.05883	16.9990	38
23	.04159	.99913	.04162	24.0263	.05902	.99826	.05912	16.9150	37
24	.04188	.99912	.04191	23.8593	.05931	.99824	.05941	16.8319	36
25	.04217	.99911	.04220	23.6945	.05960	.99822	.05970	16.7496	35
26	.04246	.99910	.04250	23.5321	.05989	.99821	.05999	16.6681	34
27	.04275	.99909	.04279	23.3718	.06018	.99819	.06029	16.5874	33
28	.04304	.99907	.04308	23.2137	.06047	.99817	.06058	16.5075	32
29	.04333	.99906	.04337	23.0577	.06076	.99815	.06087	16.4283	31
30	.04362	.99905	.04366	22.9038	.06105	.99813	.06116	16.3499	30
31	.04391	.99904	.04395	22.7519	.06134	.99812	.06145	16.2722	29
32	.04420	.99902	.04424	22.6020	.06163	.99810	.06175	16.1952	28
33	.04449	.99901	.04454	22.4541	.06192	.99808	.06204	16.1190	27
34	.04478	.99900	.04483	22.3081	.06221	.99806	.06233	16.0435	26
35	.04507	.99898	.04512	22.1640	.06250	.99804	.06262	15.9687	25
36	.04536	.99897	.04541	22.0217	.06279	.99803	.06291	15.8945	24
37	.04565	.99896	.04570	21.8813	.06308	.99801	.06321	15.8211	23
38	.04594	.99894	.04599	21.7426	.06337	.99799	.06350	15.7483	22
39	.04623	.99893	.04628	21.6056	.06366	.99797	.06379	15.6762	21
40	.04653	.99892	.04658	21.4704	.06395	.99795	.06408	15.6048	20
41	.04682	.99890	.04687	21.3369	.06424	.99793	.06437	15.5340	19
42	.04711	.99889	.04716	21.2049	.06453	.99792	.06467	15.4638	18
43	.04740	.99888	.04745	21.0747	.06482	.99790	.06496	15.3943	17
44	.04769	.99886	.04774	20.9460	.06511	.99788	.06525	15.3254	16
45	.04798	.99885	.04803	20.8188	.06540	.99786	.06554	15.2571	15
46	.04827	.99883	.04833	20.6932	.06569	.99784	.06584	15.1893	14
47	.04856	.99882	.04862	20.5691	.06598	.99782	.06613	15.1222	13
48	.04885	.99881	.04891	20.4465	.06627	.99780	.06642	15.0557	12
49	.04914	.99879	.04920	20.3253	.06656	.99778	.06671	14.9898	11
50	.04943	.99878	.04949	20.2056	.06685	.99776	.06700	14.9244	10
51	.04972	.99876	.04978	20.0872	.06714	.99774	.06730	14.8596	9
52	.05001	.99875	.05007	19.9702	.06743	.99772	.06759	14.7954	8
53	.05030	.99873	.05037	19.8546	.06773	.99770	.06788	14.7317	7
54	.05059	.99872	.05066	19.7403	.06802	.99768	.06817	14.6685	6
55	.05088	.99870	.05095	19.6273	.06831	.99766	.06847	14.6059	5
56	.05117	.99869	.05124	19.5156	.06860	.99764	.06876	14.5438	4
57	.05146	.99867	.05153	19.4051	.06889	.99762	.06905	14.4823	3
58	.05175	.99866	.05182	19.2959	.06918	.99760	.06934	14.4212	2
59	.05205	.99864	.05212	19.1879	.06947	.99758	.06963	14.3607	1
60	.05234	.99863	.05241	19.0811	.06976	.99756	.06993	14.3007	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

	4°				5°			
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.
0	.06976	.99756	.06993	14.3007	.08716	.99619	.08749	11.4301
1	.07005	.99754	.07022	14.2411	.08745	.99617	.08778	11.3919
2	.07034	.99752	.07051	14.1821	.08774	.99614	.08807	11.3540
3	.07063	.99750	.07080	14.1235	.08803	.99612	.08837	11.3163
4	.07092	.99748	.07110	14.0655	.08831	.99609	.08866	11.2789
5	.07121	.99746	.07139	14.0079	.08860	.99607	.08895	11.2417
6	.07150	.99744	.07168	13.9507	.08889	.99604	.08925	11.2048
7	.07179	.99742	.07197	13.8940	.08918	.99602	.08954	11.1681
8	.07208	.99740	.07227	13.8378	.08947	.99599	.08983	11.1316
9	.07237	.99738	.07256	13.7821	.08976	.99596	.09013	11.0954
10	.07266	.99736	.07285	13.7267	.09005	.99594	.09042	11.0594
11	.07295	.99734	.07314	13.6719	.09034	.99591	.09071	11.0237
12	.07324	.99731	.07344	13.6174	.09063	.99588	.09101	10.9882
13	.07353	.99729	.07373	13.5634	.09092	.99586	.09130	10.9529
14	.07382	.99727	.07402	13.5098	.09121	.99583	.09159	10.9178
15	.07411	.99725	.07431	13.4566	.09150	.99580	.09189	10.8829
16	.07440	.99723	.07461	13.4039	.09179	.99578	.09218	10.8483
17	.07469	.99721	.07490	13.3515	.09208	.99575	.09247	10.8139
18	.07498	.99719	.07519	13.2996	.09237	.99572	.09277	10.7797
19	.07527	.99716	.07548	13.2480	.09266	.99570	.09306	10.7457
20	.07556	.99714	.07578	13.1969	.09295	.99567	.09335	10.7119
21	.07585	.99712	.07607	13.1461	.09324	.99564	.09365	10.6783
22	.07614	.99710	.07636	13.0958	.09353	.99562	.09394	10.6450
23	.07643	.99708	.07665	13.0458	.09382	.99559	.09423	10.6118
24	.07672	.99705	.07695	12.9962	.09411	.99556	.09453	10.5789
25	.07701	.99703	.07724	12.9469	.09440	.99553	.09482	10.5462
26	.07730	.99701	.07753	12.8981	.09469	.99551	.09511	10.5136
27	.07759	.99699	.07782	12.8496	.09498	.99548	.09541	10.4813
28	.07788	.99696	.07812	12.8014	.09527	.99545	.09570	10.4491
29	.07817	.99694	.07841	12.7536	.09556	.99542	.09600	10.4172
30	.07846	.99692	.07870	12.7062	.09585	.99540	.09629	10.3854
31	.07875	.99689	.07899	12.6591	.09614	.99537	.09658	10.3538
32	.07904	.99687	.07929	12.6124	.09642	.99534	.09688	10.3224
33	.07933	.99685	.07958	12.5660	.09671	.99531	.09717	10.2913
34	.07962	.99683	.07987	12.5199	.09700	.99528	.09746	10.2602
35	.07991	.99680	.08017	12.4742	.09729	.99526	.09776	10.2294
36	.08020	.99678	.08046	12.4288	.09758	.99523	.09805	10.1988
37	.08049	.99676	.08075	12.3838	.09787	.99520	.09834	10.1683
38	.08078	.99673	.08104	12.3390	.09816	.99517	.09864	10.1381
39	.08107	.99671	.08134	12.2946	.09845	.99514	.09893	10.1080
40	.08136	.99668	.08163	12.2505	.09874	.99511	.09923	10.0780
41	.08165	.99666	.08192	12.2067	.09903	.99508	.09952	10.0483
42	.08194	.99664	.08221	12.1632	.09932	.99506	.09981	10.0187
43	.08223	.99661	.08251	12.1201	.09961	.99503	.10011	9.98931
44	.08252	.99659	.08280	12.0772	.09990	.99500	.10040	9.96007
45	.08281	.99657	.08309	12.0346	.10019	.99497	.10069	9.93101
46	.08310	.99654	.08339	11.9923	.10048	.99494	.10099	9.90211
47	.08339	.99652	.08368	11.9504	.10077	.99491	.10128	9.87338
48	.08368	.99649	.08397	11.9087	.10106	.99488	.10158	9.84482
49	.08397	.99647	.08427	11.8673	.10135	.99485	.10187	9.81641
50	.08426	.99644	.08456	11.8262	.10164	.99482	.10216	9.78817
51	.08455	.99642	.08485	11.7853	.10192	.99479	.10246	9.76009
52	.08484	.99639	.08514	11.7448	.10221	.99476	.10275	9.73217
53	.08513	.99637	.08544	11.7045	.10250	.99473	.10305	9.70441
54	.08542	.99635	.08573	11.6645	.10279	.99470	.10334	9.67680
55	.08571	.99632	.08602	11.6248	.10308	.99467	.10363	9.64935
56	.08600	.99630	.08632	11.5853	.10337	.99464	.10393	9.62205
57	.08629	.99627	.08661	11.5461	.10366	.99461	.10422	9.59490
58	.08658	.99625	.08690	11.5072	.10395	.99458	.10452	9.56791
59	.08687	.99622	.08720	11.4685	.10424	.99455	.10481	9.54106
60	.08716	.99619	.08749	11.4301	.10453	.99452	.10510	9.51436
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	6°				7°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.10453	.99452	.10510	9.51436	.12187	.99255	.12278	8.14435	60
1	.10482	.99449	.10540	9.48781	.12216	.99251	.12308	8.12481	59
2	.10511	.99446	.10569	9.46141	.12245	.99248	.12338	8.10536	58
3	.10540	.99443	.10599	9.43515	.12274	.99244	.12367	8.08600	57
4	.10569	.99440	.10628	9.40904	.12302	.99240	.12397	8.06674	56
5	.10597	.99437	.10657	9.38307	.12331	.99237	.12426	8.04756	55
6	.10626	.99434	.10687	9.35724	.12360	.99233	.12456	8.02848	54
7	.10655	.99431	.10716	9.33155	.12389	.99230	.12485	8.00948	53
8	.10684	.99428	.10746	9.30599	.12418	.99226	.12515	7.99058	52
9	.10713	.99424	.10775	9.28058	.12447	.99222	.12544	7.97176	51
10	.10742	.99421	.10805	9.25530	.12476	.99219	.12574	7.95302	50
11	.10771	.99418	.10834	9.23016	.12504	.99215	.12603	7.93438	49
12	.10800	.99415	.10863	9.20516	.12533	.99211	.12633	7.91582	48
13	.10829	.99412	.10893	9.18028	.12562	.99208	.12662	7.89734	47
14	.10858	.99409	.10922	9.15554	.12591	.99204	.12692	7.87895	46
15	.10887	.99406	.10952	9.13093	.12620	.99200	.12722	7.86064	45
16	.10916	.99402	.10981	9.10646	.12649	.99197	.12751	7.84242	44
17	.10945	.99399	.11011	9.08211	.12678	.99193	.12781	7.82428	43
18	.10973	.99396	.11040	9.05789	.12706	.99189	.12810	7.80622	42
19	.11002	.99393	.11070	9.03379	.12735	.99186	.12840	7.78825	41
20	.11031	.99390	.11099	9.00983	.12764	.99182	.12869	7.77035	40
21	.11060	.99386	.11128	8.98598	.12793	.99178	.12899	7.75254	39
22	.11089	.99383	.11158	8.96227	.12822	.99175	.12929	7.73480	38
23	.11118	.99380	.11187	8.93867	.12851	.99171	.12958	7.71715	37
24	.11147	.99377	.11217	8.91520	.12880	.99167	.12988	7.69957	36
25	.11176	.99374	.11246	8.89185	.12908	.99163	.13017	7.68208	35
26	.11205	.99370	.11276	8.86862	.12937	.99160	.13047	7.66466	34
27	.11234	.99367	.11305	8.84551	.12966	.99156	.13076	7.64732	33
28	.11263	.99364	.11335	8.82252	.12995	.99152	.13106	7.63005	32
29	.11291	.99360	.11364	8.79964	.13024	.99148	.13136	7.61287	31
30	.11320	.99357	.11394	8.77689	.13053	.99144	.13165	7.59575	30
31	.11349	.99354	.11423	8.75425	.13081	.99141	.13195	7.57872	29
32	.11378	.99351	.11452	8.73172	.13110	.99137	.13224	7.56176	28
33	.11407	.99347	.11482	8.70931	.13139	.99133	.13254	7.54487	27
34	.11436	.99344	.11511	8.68701	.13168	.99129	.13284	7.52806	26
35	.11465	.99341	.11541	8.66482	.13197	.99125	.13313	7.51132	25
36	.11494	.99337	.11570	8.64275	.13226	.99122	.13343	7.49465	24
37	.11523	.99334	.11600	8.62078	.13254	.99118	.13372	7.47806	23
38	.11552	.99331	.11629	8.59893	.13283	.99114	.13402	7.46154	22
39	.11580	.99327	.11659	8.57718	.13312	.99110	.13432	7.44509	21
40	.11609	.99324	.11688	8.55555	.13341	.99106	.13461	7.42871	20
41	.11638	.99320	.11718	8.53402	.13370	.99102	.13491	7.41240	19
42	.11667	.99317	.11747	8.51259	.13399	.99098	.13521	7.39616	18
43	.11696	.99314	.11777	8.49128	.13427	.99094	.13550	7.37999	17
44	.11725	.99310	.11806	8.47007	.13456	.99091	.13580	7.36389	16
45	.11754	.99307	.11836	8.44896	.13485	.99087	.13609	7.34786	15
46	.11783	.99303	.11865	8.42795	.13514	.99083	.13639	7.33190	14
47	.11812	.99300	.11895	8.40705	.13543	.99079	.13669	7.31600	13
48	.11840	.99297	.11924	8.38625	.13572	.99075	.13698	7.30018	12
49	.11869	.99293	.11954	8.36555	.13600	.99071	.13728	7.28442	11
50	.11898	.99290	.11983	8.34496	.13629	.99067	.13758	7.26873	10
51	.11927	.99286	.12013	8.32446	.13658	.99063	.13787	7.25310	9
52	.11956	.99283	.12042	8.30406	.13687	.99059	.13817	7.23754	8
53	.11985	.99279	.12072	8.28376	.13716	.99055	.13846	7.22204	7
54	.12014	.99276	.12101	8.26355	.13744	.99051	.13876	7.20661	6
55	.12043	.99272	.12131	8.24345	.13773	.99047	.13906	7.19125	5
56	.12071	.99269	.12160	8.22344	.13802	.99043	.13935	7.17594	4
57	.12100	.99265	.12190	8.20352	.13831	.99039	.13965	7.16071	3
58	.12129	.99262	.12219	8.18370	.13860	.99035	.13995	7.14553	2
59	.12158	.99258	.12249	8.16398	.13889	.99031	.14024	7.13042	1
60	.12187	.99255	.12278	8.14435	.13917	.99027	.14054	7.11537	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	8°				9°			
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.13917	.99027	.14054	7.11537	.15643	.98769	.15838	6.31375	60
1	.13946	.99023	.14084	7.10038	.15672	.98764	.15868	6.30189	59
2	.13975	.99019	.14113	7.08546	.15701	.98760	.15898	6.29007	58
3	.14004	.99015	.14143	7.07059	.15730	.98755	.15928	6.27829	57
4	.14033	.99011	.14173	7.05579	.15758	.98751	.15958	6.26655	56
5	.14061	.99006	.14202	7.04105	.15787	.98746	.15988	6.25486	55
6	.14090	.99002	.14232	7.02637	.15816	.98741	.16017	6.24321	54
7	.14119	.98998	.14262	7.01174	.15845	.98737	.16047	6.23160	53
8	.14148	.98994	.14291	6.99718	.15873	.98732	.16077	6.22003	52
9	.14177	.98990	.14321	6.98268	.15902	.98728	.16107	6.20851	51
10	.14205	.98986	.14351	6.96823	.15931	.98723	.16137	6.19703	50
11	.14234	.98982	.14381	6.95385	.15959	.98718	.16167	6.18559	49
12	.14263	.98978	.14410	6.93952	.15988	.98714	.16196	6.17419	48
13	.14292	.98973	.14440	6.92525	.16017	.98709	.16226	6.16283	47
14	.14320	.98969	.14470	6.91104	.16046	.98704	.16256	6.15151	46
15	.14349	.98965	.14499	6.89688	.16074	.98700	.16286	6.14023	45
16	.14378	.98961	.14529	6.88278	.16103	.98695	.16316	6.12899	44
17	.14407	.98957	.14559	6.86874	.16132	.98690	.16346	6.11779	43
18	.14436	.98953	.14588	6.85475	.16160	.98686	.16376	6.10664	42
19	.14464	.98948	.14618	6.84082	.16189	.98681	.16405	6.09552	41
20	.14493	.98944	.14648	6.82694	.16218	.98676	.16435	6.08444	40
21	.14522	.98940	.14678	6.81312	.16246	.98671	.16465	6.07340	39
22	.14551	.98936	.14707	6.79936	.16275	.98667	.16495	6.06240	38
23	.14580	.98931	.14737	6.78564	.16304	.98662	.16525	6.05143	37
24	.14608	.98927	.14767	6.77199	.16333	.98657	.16555	6.04051	36
25	.14637	.98923	.14796	6.75838	.16361	.98652	.16585	6.02962	35
26	.14666	.98919	.14826	6.74483	.16390	.98648	.16615	6.01878	34
27	.14695	.98914	.14856	6.73133	.16419	.98643	.16645	6.00797	33
28	.14723	.98910	.14886	6.71789	.16447	.98638	.16674	5.99720	32
29	.14752	.98906	.14915	6.70450	.16476	.98633	.16704	5.98646	31
30	.14781	.98902	.14945	6.69116	.16505	.98629	.16734	5.97576	30
31	.14810	.98897	.14975	6.67787	.16533	.98624	.16764	5.96510	29
32	.14838	.98893	.15005	6.66463	.16562	.98619	.16794	5.95448	28
33	.14867	.98889	.15034	6.65144	.16591	.98614	.16824	5.94390	27
34	.14896	.98884	.15064	6.63831	.16620	.98609	.16854	5.93335	26
35	.14925	.98880	.15094	6.62523	.16648	.98604	.16884	5.92283	25
36	.14954	.98876	.15124	6.61219	.16677	.98600	.16914	5.91236	24
37	.14982	.98871	.15153	6.59921	.16706	.98595	.16944	5.90191	23
38	.15011	.98867	.15183	6.58627	.16734	.98590	.16974	5.89151	22
39	.15040	.98863	.15213	6.57339	.16763	.98585	.17004	5.88114	21
40	.15069	.98858	.15243	6.56055	.16792	.98580	.17033	5.87080	20
41	.15097	.98854	.15272	6.54777	.16820	.98575	.17063	5.86051	19
42	.15126	.98849	.15302	6.53503	.16849	.98570	.17093	5.85024	18
43	.15155	.98845	.15332	6.52234	.16878	.98565	.17123	5.84001	17
44	.15184	.98841	.15362	6.50970	.16906	.98561	.17153	5.82982	16
45	.15212	.98836	.15391	6.49710	.16935	.98556	.17183	5.81966	15
46	.15241	.98832	.15421	6.48456	.16964	.98551	.17213	5.80953	14
47	.15270	.98827	.15451	6.47206	.16992	.98546	.17243	5.79944	13
48	.15299	.98823	.15481	6.45961	.17021	.98541	.17273	5.78938	12
49	.15327	.98818	.15511	6.44720	.17050	.98536	.17303	5.77936	11
50	.15356	.98814	.15540	6.43484	.17078	.98531	.17333	5.76937	10
51	.15385	.98809	.15570	6.42253	.17107	.98526	.17363	5.75941	9
52	.15414	.98805	.15600	6.41026	.17136	.98521	.17393	5.74949	8
53	.15442	.98800	.15630	6.39804	.17164	.98516	.17423	5.73960	7
54	.15471	.98796	.15660	6.38587	.17193	.98511	.17453	5.72974	6
55	.15500	.98791	.15689	6.37374	.17222	.98506	.17483	5.71992	5
56	.15529	.98787	.15719	6.36165	.17250	.98501	.17513	5.71013	4
57	.15557	.98782	.15749	6.34961	.17279	.98496	.17543	5.70037	3
58	.15586	.98778	.15779	6.33761	.17308	.98491	.17573	5.69064	2
59	.15615	.98773	.15809	6.32566	.17336	.98486	.17603	5.68094	1
60	.15643	.98769	.15838	6.31375	.17365	.98481	.17633	5.67128	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	10°				11°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	·17365	·98481	·17633	5·67128	·19081	·98163	·19438	5·14455	60
1	·17393	·98476	·17663	5·66165	·19109	·98157	·19468	5·13658	59
2	·17422	·98471	·17693	5·65205	·19138	·98152	·19498	5·12862	58
3	·17451	·98466	·17723	5·64248	·19167	·98146	·19529	5·12069	57
4	·17479	·98461	·17753	5·63295	·19195	·98140	·19559	5·11279	56
5	·17508	·98455	·17783	5·62344	·19224	·98135	·19589	5·10490	55
6	·17537	·98450	·17813	5·61397	·19252	·98129	·19619	5·09704	54
7	·17565	·98445	·17843	5·60452	·19281	·98124	·19649	5·08921	53
8	·17594	·98440	·17873	5·59511	·19309	·98118	·19680	5·08139	52
9	·17623	·98435	·17903	5·58573	·19338	·98112	·19710	5·07360	51
10	·17651	·98430	·17933	5·57638	·19366	·98107	·19740	5·06584	50
11	·17680	·98425	·17963	5·56706	·19395	·98101	·19770	5·05809	49
12	·17708	·98420	·17993	5·55777	·19423	·98096	·19801	5·05037	48
13	·17737	·98414	·18023	5·54851	·19452	·98090	·19831	5·04267	47
14	·17766	·98409	·18053	5·53927	·19481	·98084	·19861	5·03499	46
15	·17794	·98404	·18083	5·53007	·19509	·98079	·19891	5·02734	45
16	·17823	·98399	·18113	5·52090	·19538	·98073	·19921	5·01971	44
17	·17852	·98394	·18143	5·51176	·19566	·98067	·19952	5·01210	43
18	·17880	·98389	·18173	5·50264	·19595	·98061	·19982	5·00451	42
19	·17909	·98383	·18203	5·49356	·19623	·98056	·20012	4·99695	41
20	·17937	·98378	·18233	5·48451	·19652	·98050	·20042	4·98940	40
21	·17966	·98373	·18263	5·47548	·19680	·98044	·20073	4·98188	39
22	·17995	·98368	·18293	5·46648	·19709	·98039	·20103	4·97438	38
23	·18023	·98362	·18323	5·45751	·19737	·98033	·20133	4·96690	37
24	·18052	·98357	·18353	5·44857	·19766	·98027	·20164	4·95945	36
25	·18081	·98352	·18384	5·43966	·19794	·98021	·20194	4·95201	35
26	·18109	·98347	·18414	5·43077	·19823	·98016	·20224	4·94460	34
27	·18138	·98341	·18444	5·42192	·19851	·98010	·20254	4·93721	33
28	·18166	·98336	·18474	5·41309	·19880	·98004	·20285	4·92984	32
29	·18195	·98331	·18504	5·40429	·19908	·97998	·20315	4·92249	31
30	·18224	·98325	·18534	5·39552	·19937	·97992	·20345	4·91516	30
31	·18252	·98320	·18564	5·38677	·19965	·97987	·20376	4·90785	29
32	·18281	·98315	·18594	5·37805	·19994	·97981	·20406	4·90056	28
33	·18309	·98310	·18624	5·36936	·20022	·97975	·20436	4·89330	27
34	·18338	·98304	·18654	5·36070	·20051	·97969	·20466	4·88605	26
35	·18367	·98299	·18684	5·35206	·20079	·97963	·20497	4·87882	25
36	·18395	·98294	·18714	5·34345	·20108	·97958	·20527	4·87162	24
37	·18424	·98288	·18745	5·33487	·20136	·97952	·20557	4·86444	23
38	·18452	·98283	·18775	5·32631	·20165	·97946	·20588	4·85727	22
39	·18481	·98277	·18805	5·31778	·20193	·97940	·20618	4·85013	21
40	·18509	·98272	·18835	5·30928	·20222	·97934	·20648	4·84300	20
41	·18538	·98267	·18865	5·30080	·20250	·97928	·20679	4·83590	19
42	·18567	·98261	·18895	5·29235	·20279	·97922	·20709	4·82882	18
43	·18595	·98256	·18925	5·28393	·20307	·97916	·20739	4·82175	17
44	·18624	·98250	·18955	5·27553	·20336	·97910	·20770	4·81471	16
45	·18652	·98245	·18986	5·26715	·20364	·97905	·20800	4·80769	15
46	·18681	·98240	·19016	5·25880	·20393	·97899	·20830	4·80068	14
47	·18710	·98234	·19046	5·25048	·20421	·97893	·20861	4·79370	13
48	·18738	·98229	·19076	5·24218	·20450	·97887	·20891	4·78673	12
49	·18767	·98223	·19106	5·23391	·20478	·97881	·20921	4·77978	11
50	·18795	·98218	·19136	5·22566	·20507	·97875	·20952	4·77286	10
51	·18824	·98212	·19166	5·21744	·20535	·97869	·20982	4·76595	9
52	·18852	·98207	·19197	5·20925	·20563	·97863	·21013	4·75906	8
53	·18881	·98201	·19227	5·20107	·20592	·97857	·21043	4·75219	7
54	·18910	·98196	·19257	5·19293	·20620	·97851	·21073	4·74534	6
55	·18938	·98190	·19287	5·18480	·20649	·97845	·21104	4·73851	5
56	·18967	·98185	·19317	5·17671	·20677	·97839	·21134	4·73170	4
57	·18995	·98179	·19347	5·16863	·20706	·97833	·21164	4·72490	3
58	·19024	·98174	·19378	5·16058	·20734	·97827	·21195	4·71813	2
59	·19052	·98168	·19408	5·15256	·20763	·97821	·21225	4·71137	1
60	·19081	·98163	·19438	5·14455	·20791	·97815	·21256	4·70463	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII. — NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	12°				13°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.20791	.97815	.21256	4.70463	.22495	.97437	.23087	4.33148	60
1	.20820	.97809	.21286	4.69791	.22523	.97430	.23117	4.32573	59
2	.20848	.97803	.21316	4.69121	.22552	.97424	.23148	4.32001	58
3	.20877	.97797	.21347	4.68452	.22580	.97417	.23179	4.31430	57
4	.20905	.97791	.21377	4.67786	.22608	.97411	.23209	4.30860	56
5	.20933	.97784	.21408	4.67121	.22637	.97404	.23240	4.30291	55
6	.20962	.97778	.21438	4.66458	.22665	.97398	.23271	4.29724	54
7	.20990	.97772	.21469	4.65797	.22693	.97391	.23301	4.29159	53
8	.21019	.97766	.21499	4.65138	.22722	.97384	.23332	4.28595	52
9	.21047	.97760	.21529	4.64480	.22750	.97378	.23363	4.28032	51
10	.21076	.97754	.21560	4.63825	.22778	.97371	.23393	4.27471	50
11	.21104	.97748	.21590	4.63171	.22807	.97365	.23424	4.26911	49
12	.21132	.97742	.21621	4.62518	.22835	.97358	.23455	4.26352	48
13	.21161	.97735	.21651	4.61868	.22863	.97351	.23485	4.25795	47
14	.21189	.97729	.21682	4.61219	.22892	.97345	.23516	4.25239	46
15	.21218	.97723	.21712	4.60572	.22920	.97338	.23547	4.24685	45
16	.21246	.97717	.21743	4.59927	.22948	.97331	.23578	4.24132	44
17	.21275	.97711	.21773	4.59283	.22977	.97325	.23608	4.23580	43
18	.21303	.97705	.21804	4.58641	.23005	.97318	.23639	4.23030	42
19	.21331	.97698	.21834	4.58001	.23033	.97311	.23670	4.22481	41
20	.21360	.97692	.21864	4.57363	.23062	.97304	.23700	4.21933	40
21	.21388	.97686	.21895	4.56726	.23090	.97298	.23731	4.21387	39
22	.21417	.97680	.21925	4.56091	.23118	.97291	.23762	4.20842	38
23	.21445	.97673	.21956	4.55458	.23146	.97284	.23793	4.20298	37
24	.21474	.97667	.21986	4.54826	.23175	.97278	.23823	4.19756	36
25	.21502	.97661	.22017	4.54196	.23203	.97271	.23854	4.19215	35
26	.21530	.97655	.22047	4.53568	.23231	.97264	.23885	4.18675	34
27	.21559	.97648	.22078	4.52941	.23260	.97257	.23916	4.18137	33
28	.21587	.97642	.22108	4.52316	.23288	.97251	.23946	4.17600	32
29	.21616	.97636	.22139	4.51693	.23316	.97244	.23977	4.17064	31
30	.21644	.97630	.22169	4.51071	.23345	.97237	.24008	4.16530	30
31	.21672	.97623	.22200	4.50451	.23373	.97230	.24039	4.15997	29
32	.21701	.97617	.22231	4.49832	.23401	.97223	.24069	4.15465	28
33	.21729	.97611	.22261	4.49215	.23429	.97217	.24100	4.14934	27
34	.21758	.97604	.22292	4.48600	.23458	.97210	.24131	4.14405	26
35	.21786	.97598	.22322	4.47986	.23486	.97203	.24162	4.13877	25
36	.21814	.97592	.22353	4.47374	.23514	.97196	.24193	4.13350	24
37	.21843	.97585	.22383	4.46764	.23542	.97189	.24223	4.12825	23
38	.21871	.97579	.22414	4.46155	.23571	.97182	.24254	4.12301	22
39	.21899	.97573	.22444	4.45548	.23599	.97176	.24285	4.11778	21
40	.21928	.97566	.22475	4.44942	.23627	.97169	.24316	4.11256	20
41	.21956	.97560	.22505	4.44338	.23656	.97162	.24347	4.10736	19
42	.21985	.97553	.22536	4.43735	.23684	.97155	.24377	4.10216	18
43	.22013	.97547	.22567	4.43134	.23712	.97148	.24408	4.09699	17
44	.22041	.97541	.22597	4.42534	.23740	.97141	.24439	4.09182	16
45	.22070	.97534	.22628	4.41936	.23769	.97134	.24470	4.08666	15
46	.22098	.97528	.22658	4.41340	.23797	.97127	.24501	4.08152	14
47	.22126	.97521	.22689	4.40745	.23825	.97120	.24532	4.07639	13
48	.22155	.97515	.22719	4.40152	.23853	.97113	.24562	4.07127	12
49	.22183	.97508	.22750	4.39560	.23882	.97106	.24593	4.06616	11
50	.22212	.97502	.22781	4.38969	.23910	.97100	.24624	4.06107	10
51	.22240	.97496	.22811	4.38381	.23938	.97093	.24655	4.05599	9
52	.22268	.97489	.22842	4.37793	.23966	.97086	.24686	4.05092	8
53	.22297	.97483	.22872	4.37207	.23995	.97079	.24717	4.04586	7
54	.22325	.97476	.22903	4.36623	.24023	.97072	.24747	4.04081	6
55	.22353	.97470	.22934	4.36040	.24051	.97065	.24778	4.03578	5
56	.22382	.97463	.22964	4.35459	.24079	.97058	.24809	4.03076	4
57	.22410	.97457	.22995	4.34879	.24108	.97051	.24840	4.02574	3
58	.22438	.97450	.23026	4.34300	.24136	.97044	.24871	4.02074	2
59	.22467	.97444	.23056	4.33723	.24164	.97037	.24902	4.01576	1
60	.22495	.97437	.23087	4.33148	.24192	.97030	.24933	4.01078	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	14°				15°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.24192	.97030	.24933	4.01078	.25882	.96593	.26795	3.73205	60
1	.24220	.97023	.24964	4.00582	.25910	.96585	.26826	3.72771	59
2	.24249	.97015	.24995	4.00086	.25938	.96578	.26857	3.72338	58
3	.24277	.97008	.25026	3.99592	.25966	.96570	.26888	3.71907	57
4	.24305	.97001	.25056	3.99099	.25994	.96562	.26920	3.71476	56
5	.24333	.96994	.25087	3.98607	.26022	.96555	.26951	3.71046	55
6	.24362	.96987	.25118	3.98117	.26050	.96547	.26982	3.70616	54
7	.24390	.96980	.25149	3.97627	.26079	.96540	.27013	3.70188	53
8	.24418	.96973	.25180	3.97139	.26107	.96532	.27044	3.69761	52
9	.24446	.96966	.25211	3.96651	.26135	.96524	.27076	3.69335	51
10	.24474	.96959	.25242	3.96165	.26163	.96517	.27107	3.68909	50
11	.24503	.96952	.25273	3.95680	.26191	.96509	.27138	3.68485	49
12	.24531	.96945	.25304	3.95196	.26219	.96502	.27169	3.68061	48
13	.24559	.96937	.25335	3.94713	.26247	.96494	.27201	3.67638	47
14	.24587	.96930	.25366	3.94232	.26275	.96486	.27232	3.67217	46
15	.24615	.96923	.25397	3.93751	.26303	.96479	.27263	3.66796	45
16	.24644	.96916	.25428	3.93271	.26331	.96471	.27294	3.66376	44
17	.24672	.96909	.25459	3.92793	.26359	.96463	.27326	3.65957	43
18	.24700	.96902	.25490	3.92316	.26387	.96456	.27357	3.65538	42
19	.24728	.96894	.25521	3.91839	.26415	.96448	.27388	3.65121	41
20	.24756	.96887	.25552	3.91364	.26443	.96440	.27419	3.64705	40
21	.24784	.96880	.25583	3.90890	.26471	.96433	.27451	3.64289	39
22	.24813	.96873	.25614	3.90417	.26500	.96425	.27482	3.63874	38
23	.24841	.96866	.25645	3.89945	.26528	.96417	.27513	3.63461	37
24	.24869	.96858	.25676	3.89474	.26556	.96410	.27545	3.63048	36
25	.24897	.96851	.25707	3.89004	.26584	.96402	.27576	3.62636	35
26	.24925	.96844	.25738	3.88536	.26612	.96394	.27607	3.62224	34
27	.24954	.96837	.25769	3.88068	.26640	.96386	.27638	3.61814	33
28	.24982	.96829	.25800	3.87601	.26668	.96379	.27670	3.61405	32
29	.25010	.96822	.25831	3.87136	.26696	.96371	.27701	3.60996	31
30	.25038	.96815	.25862	3.86671	.26724	.96363	.27732	3.60588	30
31	.25066	.96807	.25893	3.86208	.26752	.96355	.27764	3.60181	29
32	.25094	.96800	.25924	3.85745	.26780	.96347	.27795	3.59775	28
33	.25122	.96793	.25955	3.85284	.26808	.96340	.27826	3.59370	27
34	.25151	.96786	.25986	3.84824	.26836	.96332	.27858	3.58966	26
35	.25179	.96778	.26017	3.84364	.26864	.96324	.27889	3.58562	25
36	.25207	.96771	.26048	3.83906	.26892	.96316	.27921	3.58160	24
37	.25235	.96764	.26079	3.83449	.26920	.96308	.27952	3.57758	23
38	.25263	.96756	.26110	3.82992	.26948	.96301	.27983	3.57357	22
39	.25291	.96749	.26141	3.82537	.26976	.96293	.28015	3.56957	21
40	.25320	.96742	.26172	3.82083	.27004	.96285	.28046	3.56557	20
41	.25348	.96734	.26203	3.81630	.27032	.96277	.28077	3.56159	19
42	.25376	.96727	.26235	3.81177	.27060	.96269	.28109	3.55761	18
43	.25404	.96719	.26266	3.80726	.27088	.96261	.28140	3.55364	17
44	.25432	.96712	.26297	3.80276	.27116	.96253	.28172	3.54968	16
45	.25460	.96705	.26328	3.79827	.27144	.96246	.28203	3.54573	15
46	.25488	.96697	.26359	3.79378	.27172	.96238	.28234	3.54179	14
47	.25516	.96690	.26390	3.78931	.27200	.96230	.28266	3.53785	13
48	.25545	.96682	.26421	3.78485	.27228	.96222	.28297	3.53393	12
49	.25573	.96675	.26452	3.78040.	.27256	.96214	.28329	3.53001	11
50	.25601	.96667	.26483	3.77595	.27284	.96206	.28360	3.52609	10
51	.25629	.96660	.26515	3.77152	.27312	.96198	.28391	3.52219	9
52	.25657	.96653	.26546	3.76709	.27340	.96190	.28423	3.51829	8
53	.25685	.96645	.26577	3.76268	.27368	.96182	.28454	3.51441	7
54	.25713	.96638	.26608	3.75828	.27396	.96174	.28486	3.51053	6
55	.25741	.96630	.26639	3.75388	.27424	.96166	.28517	3.50666	5
56	.25769	.96623	.26670	3.74950	.27452	.96158	.28549	3.50279	4
57	.25798	.96615	.26701	3.74512	.27480	.96150	.28580	3.49894	3
58	.25826	.96608	.26733	3.74075	.27508	.96142	.28612	3.49509	2
59	.25854	.96600	.26764	3.73640	.27536	.96134	.28643	3.49125	1
60	.25882	.96593	.26795	3.73205	.27564	.96126	.28675	3.48741	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	16°				17°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.27564	.96126	.28675	3.48741	.29237	.95630	.30573	3.27085	60
1	.27592	.96118	.28706	3.48359	.29265	.95622	.30605	3.26745	59
2	.27620	.96110	.28738	3.47977	.29293	.95613	.30637	3.26406	58
3	.27648	.96102	.28769	3.47596	.29321	.95605	.30669	3.26067	57
4	.27676	.96094	.28800	3.47216	.29348	.95596	.30700	3.25729	56
5	.27704	.96086	.28832	3.46837	.29376	.95588	.30732	3.25392	55
6	.27731	.96078	.28864	3.46458	.29404	.95579	.30764	3.25055	54
7	.27759	.96070	.28895	3.46080	.29432	.95571	.30796	3.24719	53
8	.27787	.96062	.28927	3.45703	.29460	.95562	.30828	3.24383	52
9	.27815	.96054	.28958	3.45327	.29487	.95554	.30860	3.24049	51
10	.27843	.96046	.28990	3.44951	.29515	.95545	.30891	3.23714	50
11	.27871	.96037	.29021	3.44576	.29543	.95536	.30923	3.23381	49
12	.27899	.96029	.29053	3.44202	.29571	.95528	.30955	3.23048	48
13	.27927	.96021	.29084	3.43829	.29599	.95519	.30987	3.22715	47
14	.27955	.96013	.29116	3.43456	.29626	.95511	.31019	3.22384	46
15	.27983	.96005	.29147	3.43084	.29654	.95502	.31051	3.22053	45
16	.28011	.95997	.29179	3.42713	.29682	.95493	.31083	3.21722	44
17	.28039	.95989	.29210	3.42343	.29710	.95485	.31115	3.21392	43
18	.28067	.95981	.29242	3.41973	.29737	.95476	.31147	3.21063	42
19	.28095	.95972	.29274	3.41604	.29765	.95467	.31178	3.20734	41
20	.28123	.95964	.29305	3.41236	.29793	.95459	.31210	3.20406	40
21	.28150	.95956	.29337	3.40869	.29821	.95450	.31242	3.20079	39
22	.28178	.95948	.29368	3.40502	.29849	.95441	.31274	3.19752	38
23	.28206	.95940	.29400	3.40136	.29876	.95433	.31306	3.19426	37
24	.28234	.95931	.29432	3.39771	.29904	.95424	.31338	3.19100	36
25	.28262	.95923	.29463	3.39406	.29932	.95415	.31370	3.18775	35
26	.28290	.95915	.29495	3.39042	.29960	.95407	.31402	3.18451	34
27	.28318	.95907	.29526	3.38679	.29987	.95398	.31434	3.18127	33
28	.28346	.95898	.29558	3.38317	.30015	.95389	.31466	3.17804	32
29	.28374	.95890	.29590	3.37955	.30043	.95380	.31498	3.17481	31
30	.28402	.95882	.29621	3.37594	.30071	.95372	.31530	3.17159	30
31	.28429	.95874	.29653	3.37234	.30098	.95363	.31562	3.16838	29
32	.28457	.95865	.29685	3.36875	.30126	.95354	.31594	3.16517	28
33	.28485	.95857	.29716	3.36516	.30154	.95345	.31626	3.16197	27
34	.28513	.95849	.29748	3.36158	.30182	.95337	.31658	3.15877	26
35	.28541	.95841	.29780	3.35800	.30209	.95328	.31690	3.15558	25
36	.28569	.95832	.29811	3.35443	.30237	.95319	.31722	3.15240	24
37	.28597	.95824	.29843	3.35087	.30265	.95310	.31754	3.14922	23
38	.28625	.95816	.29875	3.34732	.30292	.95301	.31786	3.14605	22
39	.28652	.95807	.29906	3.34377	.30320	.95293	.31818	3.14288	21
40	.28680	.95799	.29938	3.34023	.30348	.95284	.31850	3.13972	20
41	.28708	.95791	.29970	3.33670	.30376	.95275	.31882	3.13656	19
42	.28736	.95782	.30001	3.33317	.30403	.95266	.31914	3.13341	18
43	.28764	.95774	.30033	3.32965	.30431	.95257	.31946	3.13027	17
44	.28792	.95766	.30065	3.32614	.30459	.95248	.31978	3.12713	16
45	.28820	.95757	.30097	3.32264	.30486	.95240	.32010	3.12400	15
46	.28847	.95749	.30128	3.31914	.30514	.95231	.32042	3.12087	14
47	.28875	.95740	.30160	3.31565	.30542	.95222	.32074	3.11775	13
48	.28903	.95732	.30192	3.31216	.30570	.95213	.32106	3.11464	12
49	.28931	.95724	.30224	3.30868	.30597	.95204	.32139	3.11153	11
50	.28959	.95715	.30255	3.30521	.30625	.95195	.32171	3.10842	10
51	.28987	.95707	.30287	3.30174	.30653	.95186	.32203	3.10532	9
52	.29015	.95698	.30319	3.29829	.30680	.95177	.32235	3.10223	8
53	.29042	.95690	.30351	3.29483	.30708	.95168	.32267	3.09914	7
54	.29070	.95681	.30382	3.29139	.30736	.95159	.32299	3.09606	6
55	.29098	.95673	.30414	3.28795	.30763	.95150	.32331	3.09298	5
56	.29126	.95664	.30446	3.28452	.30791	.95142	.32363	3.08991	4
57	.29154	.95656	.30478	3.28109	.30819	.95133	.32396	3.08685	3
58	.29182	.95647	.30509	3.27767	.30846	.95124	.32428	3.08379	2
59	.29209	.95639	.30541	3.27426	.30874	.95115	.32460	3.08073	1
60	.29237	.95630	.30573	3.27085	.30902	.95106	.32492	3.07768	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	18°				19°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	·30902	·95106	·32492	3·07768	·32557	·94552	·34433	2·90421	60
1	·30929	·95097	·32524	3·07464	·32584	·94542	·34465	2·90147	59
2	·30957	·95088	·32556	3·07160	·32612	·94533	·34498	2·89873	58
3	·30985	·95079	·32588	3·06857	·32639	·94523	·34530	2·89600	57
4	·31012	·95070	·32621	3·06554	·32667	·94514	·34563	2·89327	56
5	·31040	·95061	·32653	3·06252	·32694	·94504	·34596	2·89055	55
6	·31068	·95052	·32685	3·05950	·32722	·94495	·34628	2·88783	54
7	·31095	·95043	·32717	3·05649	·32749	·94485	·34661	2·88511	53
8	·31123	·95033	·32749	3·05349	·32777	·94476	·34693	2·88240	52
9	·31151	·95024	·32782	3·05049	·32804	·94466	·34726	2·87970	51
10	·31178	·95015	·32814	3·04749	·32832	·94457	·34758	2·87700	50
11	·31206	·95006	·32846	3·04450	·32859	·94447	·34791	2·87430	49
12	·31233	·94997	·32878	3·04152	·32887	·94438	·34824	2·87161	48
13	·31261	·94988	·32911	3·03854	·32914	·94428	·34856	2·86892	47
14	·31289	·94979	·32943	3·03556	·32942	·94418	·34889	2·86624	46
15	·31316	·94970	·32975	3·03260	·32969	·94409	·34922	2·86356	45
16	·31344	·94961	·33007	3·02963	·32997	·94399	·34954	2·86089	44
17	·31372	·94952	·33040	3·02667	·33024	·94390	·34987	2·85822	43
18	·31399	·94943	·33072	3·02372	·33051	·94380	·35020	2·85555	42
19	·31427	·94933	·33104	3·02077	·33079	·94370	·35052	2·85289	41
20	·31454	·94924	·33136	3·01783	·33106	·94361	·35085	2·85023	40
21	·31482	·94915	·33169	3·01489	·33134	·94351	·35118	2·84758	39
22	·31510	·94906	·33201	3·01196	·33161	·94342	·35150	2·84494	38
23	·31537	·94897	·33233	3·00903	·33189	·94332	·35183	2·84229	37
24	·31565	·94888	·33266	3·00611	·33216	·94322	·35216	2·83965	36
25	·31593	·94878	·33298	3·00319	·33244	·94313	·35248	2·83702	35
26	·31620	·94869	·33330	3·00028	·33271	·94303	·35281	2·83439	34
27	·31648	·94860	·33363	2·99738	·33298	·94293	·35314	2·83176	33
28	·31675	·94851	·33395	2·99447	·33326	·94284	·35346	2·82914	32
29	·31703	·94842	·33427	2·99158	·33353	·94274	·35379	2·82653	31
30	·31730	·94832	·33460	2·98868	·33381	·94264	·35412	2·82391	30
31	·31758	·94823	·33492	2·98580	·33408	·94254	·35445	2·82130	29
32	·31786	·94814	·33524	2·98292	·33436	·94245	·35477	2·81870	28
33	·31813	·94805	·33557	2·98004	·33463	·94235	·35510	2·81610	27
34	·31841	·94795	·33589	2·97717	·33490	·94225	·35543	2·81350	26
35	·31868	·94786	·33621	2·97430	·33518	·94215	·35576	2·81091	25
36	·31896	·94777	·33654	2·97144	·33545	·94206	·35608	2·80833	24
37	·31923	·94768	·33686	2·96858	·33573	·94196	·35641	2·80574	23
38	·31951	·94758	·33718	2·96573	·33600	·94186	·35674	2·80316	22
39	·31979	·94749	·33751	2·96288	·33627	·94176	·35707	2·80059	21
40	·32006	·94740	·33783	2·96004	·33655	·94167	·35740	2·79802	20
41	·32034	·94730	·33816	2·95721	·33682	·94157	·35772	2·79545	19
42	·32061	·94721	·33848	2·95437	·33710	·94147	·35805	2·79289	18
43	·32089	·94712	·33881	2·95155	·33737	·94137	·35838	2·79033	17
44	·32116	·94702	·33913	2·94872	·33764	·94127	·35871	2·78778	16
45	·32144	·94693	·33945	2·94591	·33792	·94118	·35904	2·78523	15
46	·32171	·94684	·33978	2·94309	·33819	·94108	·35937	2·78269	14
47	·32199	·94674	·34010	2·94028	·33846	·94098	·35969	2·78014	13
48	·32227	·94665	·34043	2·93748	·33874	·94088	·36002	2·77761	12
49	·32254	·94656	·34075	2·93468	·33901	·94078	·36035	2·77507	11
50	·32282	·94646	·34108	2·93189	·33929	·94068	·36068	2·77254	10
51	·32309	·94637	·34140	2·92910	·33956	·94058	·36101	2·77002	9
52	·32337	·94627	·34173	2·92632	·33983	·94049	·36134	2·76750	8
53	·32364	·94618	·34205	2·92354	·34011	·94039	·36167	2·76498	7
54	·32392	·94609	·34238	2·92076	·34038	·94029	·36199	2·76247	6
55	·32419	·94599	·34270	2·91799	·34065	·94019	·36232	2·75996	5
56	·32447	·94590	·34303	2·91523	·34093	·94009	·36265	2·75746	4
57	·32474	·94580	·34335	2·91246	·34120	·93999	·36298	2·75496	3
58	·32502	·94571	·34368	2·90971	·34147	·93989	·36331	2·75246	2
59	·32529	·94561	·34400	2·90696	·34175	·93979	·36364	2·74997	1
60	·32557	·94552	·34433	2·90421	·34202	·93969	·36397	2·74748	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

71°	277	70°

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	20°				21°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.34202	.93969	.36397	2.74748	.35837	.93358	.38386	2.60509	60
1	.34229	.93959	.36430	2.74499	.35864	.93348	.38420	2.60283	59
2	.34257	.93949	.36463	2.74251	.35891	.93337	.38453	2.60057	58
3	.34284	.93939	.36496	2.74004	.35918	.93327	.38487	2.59831	57
4	.34311	.93929	.36529	2.73756	.35945	.93316	.38520	2.59606	56
5	.34339	.93919	.36562	2.73509	.35973	.93306	.38553	2.59381	55
6	.34366	.93909	.36595	2.73263	.36000	.93295	.38587	2.59156	54
7	.34393	.93899	.36628	2.73017	.36027	.93285	.38620	2.58932	53
8	.34421	.93889	.36661	2.72771	.36054	.93274	.38654	2.58708	52
9	.34448	.93879	.36694	2.72526	.36081	.93264	.38687	2.58484	51
10	.34475	.93869	.36727	2.72281	.36108	.93253	.38721	2.58261	50
11	.34503	.93859	.36760	2.72036	.36135	.93243	.38754	2.58038	49
12	.34530	.93849	.36793	2.71792	.36162	.93232	.38787	2.57815	48
13	.34557	.93839	.36826	2.71548	.36190	.93222	.38821	2.57593	47
14	.34584	.93829	.36859	2.71305	.36217	.93211	.38854	2.57371	46
15	.34612	.93819	.36892	2.71062	.36244	.93201	.38888	2.57150	45
16	.34639	.93809	.36925	2.70819	.36271	.93190	.38921	2.56928	44
17	.34666	.93799	.36958	2.70577	.36298	.93180	.38955	2.56707	43
18	.34694	.93789	.36991	2.70335	.36325	.93169	.38988	2.56487	42
19	.34721	.93779	.37024	2.70094	.36352	.93159	.39022	2.56266	41
20	.34748	.93769	.37057	2.69853	.36379	.93148	.39055	2.56046	40
21	.34775	.93759	.37090	2.69612	.36406	.93137	.39089	2.55827	39
22	.34803	.93748	.37123	2.69371	.36434	.93127	.39122	2.55608	38
23	.34830	.93738	.37157	2.69131	.36461	.93116	.39156	2.55389	37
24	.34857	.93728	.37190	2.68892	.36488	.93106	.39190	2.55170	36
25	.34884	.93718	.37223	2.68653	.36515	.93095	.39223	2.54952	35
26	.34912	.93708	.37256	2.68414	.36542	.93084	.39257	2.54734	34
27	.34939	.93698	.37289	2.68175	.36569	.93074	.39290	2.54516	33
28	.34966	.93688	.37322	2.67937	.36596	.93063	.39324	2.54299	32
29	.34993	.93677	.37355	2.67700	.36623	.93052	.39357	2.54082	31
30	.35021	.93667	.37388	2.67462	.36650	.93042	.39391	2.53865	30
31	.35048	.93657	.37422	2.67225	.36677	.93031	.39425	2.53648	29
32	.35075	.93647	.37455	2.66989	.36704	.93020	.39458	2.53432	28
33	.35102	.93637	.37488	2.66752	.36731	.93010	.39492	2.53217	27
34	.35130	.93626	.37521	2.66516	.36758	.92999	.39526	2.53001	26
35	.35157	.93616	.37554	2.66281	.36785	.92988	.39559	2.52786	25
36	.35184	.93606	.37588	2.66046	.36812	.92978	.39593	2.52571	24
37	.35211	.93596	.37621	2.65811	.36839	.92967	.39626	2.52357	23
38	.35239	.93585	.37654	2.65576	.36867	.92956	.39660	2.52142	22
39	.35266	.93575	.37687	2.65342	.36894	.92945	.39694	2.51929	21
40	.35293	.93565	.37720	2.65109	.36921	.92935	.39727	2.51715	20
41	.35320	.93555	.37754	2.64875	.36948	.92924	.39761	2.51502	19
42	.35347	.93544	.37787	2.64642	.36975	.92913	.39795	2.51289	18
43	.35375	.93534	.37820	2.64410	.37002	.92902	.39829	2.51076	17
44	.35402	.93524	.37853	2.64177	.37029	.92892	.39862	2.50864	16
45	.35429	.93514	.37887	2.63945	.37056	.92881	.39896	2.50652	15
46	.35456	.93503	.37920	2.63714	.37083	.92870	.39930	2.50440	14
47	.35484	.93493	.37953	2.63483	.37110	.92859	.39963	2.50229	13
48	.35511	.93483	.37986	2.63252	.37137	.92849	.39997	2.50018	12
49	.35538	.93472	.38020	2.63021	.37164	.92838	.40031	2.49807	11
50	.35565	.93462	.38053	2.62791	.37191	.92827	.40065	2.49597	10
51	.35592	.93452	.38086	2.62561	.37218	.92816	.40098	2.49386	9
52	.35619	.93441	.38120	2.62332	.37245	.92805	.40132	2.49177	8
53	.35647	.93431	.38153	2.62103	.37272	.92794	.40166	2.48967	7
54	.35674	.93420	.38186	2.61874	.37299	.92784	.40200	2.48758	6
55	.35701	.93410	.38220	2.61646	.37326	.92773	.40234	2.48549	5
56	.35728	.93400	.38253	2.61418	.37353	.92762	.40267	2.48340	4
57	.35755	.93389	.38286	2.61190	.37380	.92751	.40301	2.48132	3
58	.35782	.93379	.38320	2.60963	.37407	.92740	.40335	2.47924	2
59	.35810	.93368	.38353	2.60736	.37434	.92729	.40369	2.47716	1
60	.35837	.93358	.38386	2.60509	.37461	.92718	.40403	2.47509	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

69°	278	68°

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	22°				23°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	·37461	·92718	·40403	2·47509	·39073	·92050	·42447	2·35585	60
1	·37488	·92707	·40436	2·47302	·39100	·92039	·42482	2·35395	59
2	·37515	·92697	·40470	2·47095	·39127	·92028	·42516	2·35205	58
3	·37542	·92686	·40504	2·46888	·39153	·92016	·42551	2·35015	57
4	·37569	·92675	·40538	2·46682	·39180	·92005	·42585	2·34825	56
5	·37595	·92664	·40572	2·46476	·39207	·91994	·42619	2·34636	55
6	·37622	·92653	·40606	2·46270	·39234	·91982	·42654	2·34447	54
7	·37649	·92642	·40640	2·46065	·39260	·91971	·42688	2·34258	53
8	·37676	·92631	·40674	2·45860	·39287	·91959	·42722	2·34069	52
9	·37703	·92620	·40707	2·45655	·39314	·91948	·42757	2·33881	51
10	·37730	·92609	·40741	2·45451	·39341	·91936	·42791	2·33693	50
11	·37757	·92598	·40775	2·45246	·39367	·91925	·42826	2·33505	49
12	·37784	·92587	·40809	2·45043	·39394	·91914	·42860	2·33317	48
13	·37811	·92576	·40843	2·44839	·39421	·91902	·42894	2·33130	47
14	·37838	·92565	·40877	2·44636	·39448	·91891	·42929	2·32943	46
15	·37865	·92554	·40911	2·44433	·39474	·91879	·42963	2·32756	45
16	·37892	·92543	·40945	2·44230	·39501	·91868	·42998	2·32570	44
17	·37919	·92532	·40979	2·44027	·39528	·91856	·43032	2·32383	43
18	·37946	·92521	·41013	2·43825	·39555	·91845	·43067	2·32197	42
19	·37973	·92510	·41047	2·43623	·39581	·91833	·43101	2·32012	41
20	·37999	·92499	·41081	2·43422	·39608	·91822	·43136	2·31826	40
21	·38026	·92488	·41115	2·43220	·39635	·91810	·43170	2·31641	39
22	·38053	·92477	·41149	2·43019	·39661	·91799	·43205	2·31456	38
23	·38080	·92466	·41183	2·42819	·39688	·91787	·43239	2·31271	37
24	·38107	·92455	·41217	2·42618	·39715	·91775	·43274	2·31086	36
25	·38134	·92444	·41251	2·42418	·39741	·91764	·43308	2·30902	35
26	·38161	·92432	·41285	2·42218	·39768	·91752	·43343	2·30718	34
27	·38188	·92421	·41319	2·42019	·39795	·91741	·43378	2·30534	33
28	·38215	·92410	·41353	2·41819	·39822	·91729	·43412	2·30351	32
29	·38241	·92399	·41387	2·41620	·39848	·91718	·43447	2·30167	31
30	·38268	·92388	·41421	2·41421	·39875	·91706	·43481	2·29984	30
31	·38295	·92377	·41455	2·41223	·39902	·91694	·43516	2·29801	29
32	·38322	·92366	·41490	2·41025	·39928	·91683	·43550	2·29619	28
33	·38349	·92355	·41524	2·40827	·39955	·91671	·43585	2·29437	27
34	·38376	·92343	·41558	2·40629	·39982	·91660	·43620	2·29254	26
35	·38403	·92332	·41592	2·40432	·40008	·91648	·43654	2·29073	25
36	·38430	·92321	·41626	2·40235	·40035	·91636	·43689	2·28891	24
37	·38456	·92310	·41660	2·40038	·40062	·91625	·43724	2·28710	23
38	·38483	·92299	·41694	2·39841	·40088	·91613	·43758	2·28528	22
39	·38510	·92287	·41728	2·39645	·40115	·91601	·43793	2·28348	21
40	·38537	·92276	·41763	2·39449	·40141	·91590	·43828	2·28167	20
41	·38564	·92265	·41797	2·39253	·40168	·91578	·43862	2·27987	19
42	·38591	·92254	·41831	2·39058	·40195	·91566	·43897	2·27806	18
43	·38617	·92243	·41865	2·38863	·40221	·91555	·43932	2·27626	17
44	·38644	·92231	·41899	2·38668	·40248	·91543	·43966	2·27447	16
45	·38671	·92220	·41933	2·38473	·40275	·91531	·44001	2·27267	15
46	·38698	·92209	·41968	2·38279	·40301	·91519	·44036	2·27088	14
47	·38725	·92198	·42002	2·38084	·40328	·91508	·44071	2·26909	13
48	·38752	·92186	·42036	2·37891	·40355	·91496	·44105	2·26730	12
49	·38778	·92175	·42070	2·37697	·40381	·91484	·44140	2·26552	11
50	·38805	·92164	·42105	2·37504	·40408	·91472	·44175	2·26374	10
51	·38832	·92152	·42139	2·37311	·40434	·91461	·44210	2·26196	9
52	·38859	·92141	·42173	2·37118	·40461	·91449	·44244	2·26018	8
53	·38886	·92130	·42207	2·36925	·40488	·91437	·44279	2·25840	7
54	·38912	·92119	·42242	2·36733	·40514	·91425	·44314	2·25663	6
55	·38939	·92107	·42276	2·36541	·40541	·91414	·44349	2·25486	5
56	·38966	·92096	·42310	2·36349	·40567	·91402	·44384	2·25309	4
57	·38993	·92085	·42345	2·36158	·40594	·91390	·44418	2·25132	3
58	·39020	·92073	·42379	2·35967	·40621	·91378	·44453	2·24956	2
59	·39046	·92062	·42413	2·35776	·40647	·91366	·44488	2·24780	1
60	·39073	·92050	·42447	2·35585	·40674	·91355	·44523	2·24604	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

	24°				25°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.40674	.91355	.44523	2.24604	.42262	.90631	.46631	2.14451	60
1	.40700	.91343	.44558	2.24428	.42288	.90618	.46666	2.14288	59
2	.40727	.91331	.44593	2.24252	.42315	.90606	.46702	2.14125	58
3	.40753	.91319	.44627	2.24077	.42341	.90594	.46737	2.13963	57
4	.40780	.91307	.44662	2.23902	.42367	.90582	.46772	2.13801	56
5	.40806	.91295	.44697	2.23727	.42394	.90569	.46808	2.13639	55
6	.40833	.91283	.44732	2.23553	.42420	.90557	.46843	2.13477	54
7	.40860	.91272	.44767	2.23378	.42446	.90545	.46879	2.13316	53
8	.40886	.91260	.44802	2.23204	.42473	.90532	.46914	2.13154	52
9	.40913	.91248	.44837	2.23030	.42499	.90520	.46950	2.12993	51
10	.40939	.91236	.44872	2.22857	.42525	.90507	.46985	2.12832	50
11	.40966	.91224	.44907	2.22683	.42552	.90495	.47021	2.12671	49
12	.40992	.91212	.44942	2.22510	.42578	.90483	.47056	2.12511	48
13	.41019	.91200	.44977	2.22337	.42604	.90470	.47092	2.12350	47
14	.41045	.91188	.45012	2.22164	.42631	.90458	.47128	2.12190	46
15	.41072	.91176	.45047	2.21992	.42657	.90446	.47163	2.12030	45
16	.41098	.91164	.45082	2.21819	.42683	.90433	.47199	2.11871	44
17	.41125	.91152	.45117	2.21647	.42709	.90421	.47234	2.11711	43
18	.41151	.91140	.45152	2.21475	.42736	.90408	.47270	2.11552	42
19	.41178	.91128	.45187	2.21304	.42762	.90396	.47305	2.11392	41
20	.41204	.91116	.45222	2.21132	.42788	.90383	.47341	2.11233	40
21	.41231	.91104	.45257	2.20961	.42815	.90371	.47377	2.11075	39
22	.41257	.91092	.45292	2.20790	.42841	.90358	.47412	2.10916	38
23	.41284	.91080	.45327	2.20619	.42867	.90346	.47448	2.10758	37
24	.41310	.91068	.45362	2.20449	.42894	.90334	.47483	2.10600	36
25	.41337	.91056	.45397	2.20278	.42920	.90321	.47519	2.10442	35
26	.41363	.91044	.45432	2.20108	.42946	.90309	.47555	2.10284	34
27	.41390	.91032	.45467	2.19938	.42972	.90296	.47590	2.10126	33
28	.41416	.91020	.45502	2.19769	.42999	.90284	.47626	2.09969	32
29	.41443	.91008	.45538	2.19599	.43025	.90271	.47662	2.09811	31
30	.41469	.90996	.45573	2.19430	.43051	.90259	.47698	2.09654	30
31	.41496	.90984	.45608	2.19261	.43077	.90246	.47733	2.09498	29
32	.41522	.90972	.45643	2.19092	.43104	.90233	.47769	2.09341	28
33	.41549	.90960	.45678	2.18923	.43130	.90221	.47805	2.09184	27
34	.41575	.90948	.45713	2.18755	.43156	.90208	.47840	2.09028	26
35	.41602	.90936	.45748	2.18587	.43182	.90196	.47876	2.08872	25
36	.41628	.90924	.45784	2.18419	.43209	.90183	.47912	2.08716	24
37	.41655	.90911	.45819	2.18251	.43235	.90171	.47948	2.08560	23
38	.41681	.90899	.45854	2.18084	.43261	.90158	.47984	2.08405	22
39	.41707	.90887	.45889	2.17916	.43287	.90146	.48019	2.08250	21
40	.41734	.90875	.45924	2.17749	.43313	.90133	.48055	2.08094	20
41	.41760	.90863	.45960	2.17582	.43340	.90120	.48091	2.07939	19
42	.41787	.90851	.45995	2.17416	.43366	.90108	.48127	2.07785	18
43	.41813	.90839	.46030	2.17249	.43392	.90095	.48163	2.07630	17
44	.41840	.90826	.46065	2.17083	.43418	.90082	.48198	2.07476	16
45	.41866	.90814	.46101	2.16917	.43445	.90070	.48234	2.07321	15
46	.41892	.90802	.46136	2.16751	.43471	.90057	.48270	2.07167	14
47	.41919	.90790	.46171	2.16585	.43497	.90045	.48306	2.07014	13
48	.41945	.90778	.46206	2.16420	.43523	.90032	.48342	2.06860	12
49	.41972	.90766	.46242	2.16255	.43549	.90019	.48378	2.06706	11
50	.41998	.90753	.46277	2.16090	.43575	.90007	.48414	2.06553	10
51	.42024	.90741	.46312	2.15925	.43602	.89994	.48450	2.06400	9
52	.42051	.90729	.46348	2.15760	.43628	.89981	.48486	2.06247	8
53	.42077	.90717	.46383	2.15596	.43654	.89968	.48521	2.06094	7
54	.42104	.90704	.46418	2.15432	.43680	.89956	.48557	2.05942	6
55	.42130	.90692	.46454	2.15268	.43706	.89943	.48593	2.05790	5
56	.42156	.90680	.46489	2.15104	.43733	.89930	.48629	2.05637	4
57	.42183	.90668	.46525	2.14940	.43759	.89918	.48665	2.05485	3
58	.42209	.90655	.46560	2.14777	.43785	.89905	.48701	2.05333	2
59	.42235	.90643	.46595	2.14614	.43811	.89892	.48737	2.05182	1
60	.42262	.90631	.46631	2.14451	.43837	.89879	.48773	2.05030	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	26°				27°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	·43837	·89879	·48773	2·05030	·45399	·89101	·50953	1·96261	60
1	·43863	·89867	·48809	2·04879	·45425	·89087	·50989	1·96120	59
2	·43889	·89854	·48845	2·04728	·45451	·89074	·51026	1·95979	58
3	·43916	·89841	·48881	2·04577	·45477	·89061	·51063	1·95838	57
4	·43942	·89828	·48917	2·04426	·45503	·89048	·51099	1·95698	56
5	·43968	·89816	·48953	2·04276	·45529	·89035	·51136	1·95557	55
6	·43994	·89803	·48989	2·04125	·45554	·89021	·51173	1·95417	54
7	·44020	·89790	·49026	2·03975	·45580	·89008	·51209	1·95277	53
8	·44046	·89777	·49062	2·03825	·45606	·88995	·51246	1·95137	52
9	·44072	·89764	·49098	2·03675	·45632	·88981	·51283	1·94997	51
10	·44098	·89752	·49134	2·03526	·45658	·88968	·51319	1·94858	50
11	·44124	·89739	·49170	2·03376	·45684	·88955	·51356	1·94718	49
12	·44151	·89726	·49206	2·03227	·45710	·88942	·51393	1·94579	48
13	·44177	·89713	·49242	2·03078	·45736	·88928	·51430	1·94440	47
14	·44203	·89700	·49278	2·02929	·45762	·88915	·51467	1·94301	46
15	·44229	·89687	·49315	2·02780	·45787	·88902	·51503	1·94162	45
16	·44255	·89674	·49351	2·02631	·45813	·88888	·51540	1·94023	44
17	·44281	·89662	·49387	2·02483	·45839	·88875	·51577	1·93885	43
18	·44307	·89649	·49423	2·02335	·45865	·88862	·51614	1·93746	42
19	·44333	·89636	·49459	2·02187	·45891	·88848	·51651	1·93608	41
20	·44359	·89623	·49495	2·02039	·45917	·88835	·51688	1·93470	40
21	·44385	·89610	·49532	2·01891	·45942	·88822	·51724	1·93332	39
22	·44411	·89597	·49568	2·01743	·45968	·88808	·51761	1·93195	38
23	·44437	·89584	·49604	2·01596	·45994	·88795	·51798	1·93057	37
24	·44464	·89571	·49640	2·01449	·46020	·88782	·51835	1·92920	36
25	·44490	·89558	·49677	2·01302	·46046	·88768	·51872	1·92782	35
26	·44516	·89545	·49713	2·01155	·46072	·88755	·51909	1·92645	34
27	·44542	·89532	·49749	2·01008	·46097	·88741	·51946	1·92508	33
28	·44568	·89519	·49786	2·00862	·46123	·88728	·51983	1·92371	32
29	·44594	·89506	·49822	2·00715	·46149	·88715	·52020	1·92235	31
30	·44620	·89493	·49858	2·00569	·46175	·88701	·52057	1·92098	30
31	·44646	·89480	·49894	2·00423	·46201	·88688	·52094	1·91962	29
32	·44672	·89467	·49931	2·00277	·46226	·88674	·52131	1·91826	28
33	·44698	·89454	·49967	2·00131	·46252	·88661	·52168	1·91690	27
34	·44724	·89441	·50004	1·99986	·46278	·88647	·52205	1·91554	26
35	·44750	·89428	·50040	1·99841	·46304	·88634	·52242	1·91418	25
36	·44776	·89415	·50076	1·99695	·46330	·88620	·52279	1·91282	24
37	·44802	·89402	·50113	1·99550	·46355	·88607	·52316	1·91147	23
38	·44828	·89389	·50149	1·99406	·46381	·88593	·52353	1·91012	22
39	·44854	·89376	·50185	1·99261	·46407	·88580	·52390	1·90878	21
40	·44880	·89363	·50222	1·99116	·46433	·88566	·52427	1·90741	20
41	·44906	·89350	·50258	1·98972	·46458	·88553	·52464	1·90607	19
42	·44932	·89337	·50295	1·98828	·46484	·88539	·52501	1·90472	18
43	·44958	·89324	·50331	1·98684	·46510	·88526	·52538	1·90337	17
44	·44984	·89311	·50368	1·98540	·46536	·88512	·52575	1·90203	16
45	·45010	·89298	·50404	1·98396	·46561	·88499	·52613	1·90069	15
46	·45036	·89285	·50441	1·98253	·46587	·88485	·52650	1·89935	14
47	·45062	·89272	·50477	1·98110	·46613	·88472	·52687	1·89801	13
48	·45088	·89259	·50514	1·97966	·46639	·88458	·52724	1·89667	12
49	·45114	·89245	·50550	1·97823	·46664	·88445	·52761	1·89533	11
50	·45140	·89232	·50587	1·97681	·46690	·88431	·52798	1·89400	10
51	·45166	·89219	·50623	1·97538	·46716	·88417	·52836	1·89266	9
52	·45192	·89206	·50660	1·97395	·46742	·88404	·52873	1·89133	8
53	·45218	·89193	·50696	1·97253	·46767	·88390	·52910	1·89000	7
54	·45243	·89180	·50733	1·97111	·46793	·88377	·52947	1·88867	6
55	·45269	·89167	·50769	1·96969	·46819	·88363	·52985	1·88734	5
56	·45295	·89153	·50806	1·96827	·46844	·88349	·53022	1·88602	4
57	·45321	·89140	·50843	1·96685	·46870	·88336	·53059	1·88469	3
58	·45347	·89127	·50879	1·96544	·46896	·88322	·53096	1·88337	2
59	·45373	·89114	·50916	1·96402	·46921	·88308	·53134	1·88205	1
60	·45399	·89101	·50953	1·96261	·46947	·88295	·53171	1·88073	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′
	63°				62°				

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	28°			29°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.46947	.88295	.53171	1.88073	.48481	.87462	.55431	1.80405	60
1	.46973	.88281	.53208	1.87941	.48506	.87448	.55469	1.80281	59
2	.46999	.88267	.53246	1.87809	.48532	.87434	.55507	1.80158	58
3	.47024	.88254	.53283	1.87677	.48557	.87420	.55545	1.80034	57
4	.47050	.88240	.53320	1.87546	.48583	.87406	.55583	1.79911	56
5	.47076	.88226	.53358	1.87415	.48608	.87391	.55621	1.79788	55
6	.47101	.88213	.53395	1.87283	.48634	.87377	.55659	1.79665	54
7	.47127	.88199	.53432	1.87152	.48659	.87363	.55697	1.79542	53
8	.47153	.88185	.53470	1.87021	.48684	.87349	.55736	1.79419	52
9	.47178	.88172	.53507	1.86891	.48710	.87335	.55774	1.79296	51
10	.47204	.88158	.53545	1.86760	.48735	.87321	.55812	1.79174	50
11	.47229	.88144	.53582	1.86630	.48761	.87306	.55850	1.79051	49
12	.47255	.88130	.53620	1.86499	.48786	.87292	.55888	1.78929	48
13	.47281	.88117	.53657	1.86369	.48811	.87278	.55926	1.78807	47
14	.47306	.88103	.53694	1.86239	.48837	.87264	.55964	1.78685	46
15	.47332	.88089	.53732	1.86109	.48862	.87250	.56003	1.78563	45
16	.47358	.88075	.53769	1.85979	.48888	.87235	.56041	1.78441	44
17	.47383	.88062	.53807	1.85850	.48913	.87221	.56079	1.78319	43
18	.47409	.88048	.53844	1.85720	.48938	.87207	.56117	1.78198	42
19	.47434	.88034	.53882	1.85591	.48964	.87193	.56156	1.78077	41
20	.47460	.88020	.53920	1.85462	.48989	.87178	.56194	1.77955	40
21	.47486	.88006	.53957	1.85333	.49014	.87164	.56232	1.77834	39
22	.47511	.87993	.53995	1.85204	.49040	.87150	.56270	1.77713	38
23	.47537	.87979	.54032	1.85075	.49065	.87136	.56309	1.77592	37
24	.47562	.87965	.54070	1.84946	.49090	.87121	.56347	1.77471	36
25	.47588	.87951	.54107	1.84818	.49116	.87107	.56385	1.77351	35
26	.47614	.87937	.54145	1.84689	.49141	.87093	.56424	1.77230	34
27	.47639	.87923	.54183	1.84561	.49166	.87079	.56462	1.77110	33
28	.47665	.87909	.54220	1.84433	.49192	.87064	.56501	1.76990	32
29	.47690	.87896	.54258	1.84305	.49217	.87050	.56539	1.76869	31
30	.47716	.87882	.54296	1.84177	.49242	.87036	.56577	1.76749	30
31	.47741	.87868	.54333	1.84049	.49268	.87021	.56616	1.76629	29
32	.47767	.87854	.54371	1.83922	.49293	.87007	.56654	1.76510	28
33	.47793	.87840	.54409	1.83794	.49318	.86993	.56693	1.76390	27
34	.47818	.87826	.54446	1.83667	.49344	.86978	.56731	1.76271	26
35	.47844	.87812	.54484	1.83540	.49369	.86964	.56769	1.76151	25
36	.47869	.87798	.54522	1.83413	.49394	.86949	.56808	1.76032	24
37	.47895	.87784	.54560	1.83286	.49419	.86935	.56846	1.75913	23
38	.47920	.87770	.54597	1.83159	.49445	.86921	.56885	1.75794	22
39	.47946	.87756	.54635	1.83033	.49470	.86906	.56923	1.75675	21
40	.47971	.87743	.54673	1.82906	.49495	.86892	.56962	1.75556	20
41	.47997	.87729	.54711	1.82780	.49521	.86878	.57000	1.75437	19
42	.48022	.87715	.54748	1.82654	.49546	.86863	.57039	1.75319	18
43	.48048	.87701	.54786	1.82528	.49571	.86849	.57078	1.75200	17
44	.48073	.87687	.54824	1.82402	.49596	.86834	.57116	1.75082	16
45	.48099	.87673	.54862	1.82276	.49622	.86820	.57155	1.74964	15
46	.48124	.87659	.54900	1.82150	.49647	.86805	.57193	1.74846	14
47	.48150	.87645	.54938	1.82025	.49672	.86791	.57232	1.74728	13
48	.48175	.87631	.54975	1.81899	.49697	.86777	.57271	1.74610	12
49	.48201	.87617	.55013	1.81774	.49723	.86762	.57309	1.74492	11
50	.48226	.87603	.55051	1.81649	.49748	.86748	.57348	1.74375	10
51	.48252	.87589	.55089	1.81524	.49773	.86733	.57386	1.74257	9
52	.48277	.87575	.55127	1.81399	.49798	.86719	.57425	1.74140	8
53	.48303	.87561	.55165	1.81274	.49824	.86704	.57464	1.74022	7
54	.48328	.87546	.55203	1.81150	.49849	.86690	.57503	1.73905	6
55	.48354	.87532	.55241	1.81025	.49874	.86675	.57541	1.73788	5
56	.48379	.87518	.55279	1.80901	.49899	.86661	.57580	1.73671	4
57	.48405	.87504	.55317	1.80777	.49924	.86646	.57619	1.73555	3
58	.48430	.87490	.55355	1.80653	.49950	.86632	.57657	1.73438	2
59	.48456	.87476	.55393	1.80529	.49975	.86617	.57696	1.73321	1
60	.48481	.87462	.55431	1.80405	.50000	.86603	.57735	1.73205	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII. — NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	30°				31°			
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.50000	.86603	.57735	1.73205	.51504	.85717	.60086	1.66428	60
1	.50025	.86588	.57774	1.73089	.51529	.85702	.60126	1.66318	59
2	.50050	.86573	.57813	1.72973	.51554	.85687	.60165	1.66209	58
3	.50076	.86559	.57851	1.72857	.51579	.85672	.60205	1.66099	57
4	.50101	.86544	.57890	1.72741	.51604	.85657	.60245	1.65990	56
5	.50126	.86530	.57929	1.72625	.51628	.85642	.60284	1.65881	55
6	.50151	.86515	.57968	1.72509	.51653	.85627	.60324	1.65772	54
7	.50176	.86501	.58007	1.72393	.51678	.85612	.60364	1.65663	53
8	.50201	.86486	.58046	1.72278	.51703	.85597	.60403	1.65554	52
9	.50227	.86471	.58085	1.72163	.51728	.85582	.60443	1.65445	51
10	.50252	.86457	.58124	1.72047	.51753	.85567	.60483	1.65337	50
11	.50277	.86442	.58162	1.71932	.51778	.85551	.60522	1.65228	49
12	.50302	.86427	.58201	1.71817	.51803	.85536	.60562	1.65120	48
13	.50327	.86413	.58240	1.71702	.51828	.85521	.60602	1.65011	47
14	.50352	.86398	.58279	1.71588	.51852	.85506	.60642	1.64903	46
15	.50377	.86384	.58318	1.71473	.51877	.85491	.60681	1.64795	45
16	.50403	.86369	.58357	1.71358	.51902	.85476	.60721	1.64687	44
17	.50428	.86354	.58396	1.71244	.51927	.85461	.60761	1.64579	43
18	.50453	.86340	.58435	1.71129	.51952	.85446	.60801	1.64471	42
19	.50478	.86325	.58474	1.71015	.51977	.85431	.60841	1.64363	41
20	.50503	.86310	.58513	1.70901	.52002	.85416	.60881	1.64256	40
21	.50528	.86295	.58552	1.70787	.52026	.85401	.60921	1.64148	39
22	.50553	.86281	.58591	1.70673	.52051	.85385	.60960	1.64041	38
23	.50578	.86266	.58631	1.70560	.52076	.85370	.61000	1.63934	37
24	.50603	.86251	.58670	1.70446	.52101	.85355	.61040	1.63826	36
25	.50628	.86237	.58709	1.70332	.52126	.85340	.61080	1.63719	35
26	.50654	.86222	.58748	1.70219	.52151	.85325	.61120	1.63612	34
27	.50679	.86207	.58787	1.70106	.52175	.85310	.61160	1.63505	33
28	.50704	.86192	.58826	1.69992	.52200	.85294	.61200	1.63398	32
29	.50729	.86178	.58865	1.69879	.52225	.85279	.61240	1.63292	31
30	.50754	.86163	.58905	1.69766	.52250	.85264	.61280	1.63185	30
31	.50779	.86148	.58944	1.69653	.52275	.85249	.61320	1.63079	29
32	.50804	.86133	.58983	1.69541	.52299	.85234	.61360	1.62972	28
33	.50829	.86119	.59022	1.69428	.52324	.85218	.61400	1.62866	27
34	.50854	.86104	.59061	1.69316	.52349	.85203	.61440	1.62760	26
35	.50879	.86089	.59101	1.69203	.52374	.85188	.61480	1.62654	25
36	.50904	.86074	.59140	1.69091	.52399	.85173	.61520	1.62548	24
37	.50929	.86059	.59179	1.68979	.52423	.85157	.61561	1.62442	23
38	.50954	.86045	.59218	1.68866	.52448	.85142	.61601	1.62336	22
39	.50979	.86030	.59258	1.68754	.52473	.85127	.61641	1.62230	21
40	.51004	.86015	.59297	1.68643	.52498	.85112	.61681	1.62125	20
41	.51029	.86000	.59336	1.68531	.52522	.85096	.61721	1.62019	19
42	.51054	.85985	.59376	1.68419	.52547	.85081	.61761	1.61914	18
43	.51079	.85970	.59415	1.68308	.52572	.85066	.61801	1.61808	17
44	.51104	.85956	.59454	1.68196	.52597	.85051	.61842	1.61703	16
45	.51129	.85941	.59494	1.68085	.52621	.85035	.61882	1.61598	15
46	.51154	.85926	.59533	1.67974	.52646	.85020	.61922	1.61493	14
47	.51179	.85911	.59573	1.67863	.52671	.85005	.61962	1.61388	13
48	.51204	.85896	.59612	1.67752	.52696	.84989	.62003	1.61283	12
49	.51229	.85881	.59651	1.67641	.52720	.84974	.62043	1.61179	11
50	.51254	.85866	.59691	1.67530	.52745	.84959	.62083	1.61074	10
51	.51279	.85851	.59730	1.67419	.52770	.84943	.62124	1.60970	9
52	.51304	.85836	.59770	1.67309	.52794	.84928	.62164	1.60865	8
53	.51329	.85821	.59809	1.67198	.52819	.84913	.62204	1.60761	7
54	.51354	.85806	.59849	1.67088	.52844	.84897	.62245	1.60657	6
55	.51379	.85792	.59888	1.66978	.52869	.84882	.62285	1.60553	5
56	.51404	.85777	.59928	1.66867	.52893	.84866	.62325	1.60449	4
57	.51429	.85762	.59967	1.66757	.52918	.84851	.62366	1.60345	3
58	.51454	.85747	.60007	1.66647	.52943	.84836	.62406	1.60241	2
59	.51479	.85732	.60046	1.66538	.52967	.84820	.62446	1.60137	1
60	.51504	.85717	.60086	1.66428	.52992	.84805	.62487	1.60033	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

	32°			33°				
′	Sin.	Cos	Tan.	Cot	Sin.	Cos.	Tan.	Cot.	′
0	.52992	.84805	.62487	1.60033	.54464	.83867	.64941	1.53986	60
1	.53017	.84789	.62527	1.59930	.54488	.83851	.64982	1.53888	59
2	.53041	.84774	.62568	1.59826	.54513	.83835	.65024	1.53791	58
3	.53066	.84759	.62608	1.59723	.54537	.83819	.65065	1.53693	57
4	.53091	.84743	.62649	1.59620	.54561	.83804	.65106	1.53595	56
5	.53115	.84728	.62689	1.59517	.54585	.83788	.65148	1.53497	55
6	.53140	.84712	.62730	1.59414	.54610	.83772	.65189	1.53400	54
7	.53164	.84697	.62770	1.59311	.54635	.83756	.65231	1.53302	53
8	.53189	.84681	.62811	1.59208	.54659	.83740	.65272	1.53205	52
9	.53214	.84666	.62852	1.59105	.54683	.83724	.65314	1.53107	51
10	.53238	.84650	.62892	1.59002	.54708	.83708	.65355	1.53010	50
11	.53263	.84635	.62933	1.58900	.54732	.83692	.65397	1.52913	49
12	.53288	.84619	.62973	1.58797	.54756	.83676	.65438	1.52816	48
13	.53312	.84604	.63014	1.58695	.54781	.83660	.65480	1.52719	47
14	.53337	.84588	.63055	1.58593	.54805	.83645	.65521	1.52622	46
15	.53361	.84573	.63095	1.58490	.54829	.83629	.65563	1.52525	45
16	.53386	.84557	.63136	1.58388	.54854	.83613	.65604	1.52429	44
17	.53411	.84542	.63177	1.58286	.54878	.83597	.65646	1.52332	43
18	.53435	.84526	.63217	1.58184	.54902	.83581	.65688	1.52235	42
19	.53460	.84511	.63258	1.58083	.54927	.83565	.65729	1.52139	41
20	.53484	.84495	.63299	1.57981	.54951	.83549	.65771	1.52043	40
21	.53509	.84480	.63340	1.57879	.54975	.83533	.65813	1.51946	39
22	.53534	.84464	.63380	1.57778	.54999	.83517	.65854	1.51850	38
23	.53558	.84448	.63421	1.57676	.55024	.83501	.65896	1.51754	37
24	.53583	.84433	.63462	1.57575	.55048	.83485	.65938	1.51658	36
25	.53607	.84417	.63503	1.57474	.55072	.83469	.65980	1.51562	35
26	.53632	.84402	.63544	1.57372	.55097	.83453	.66021	1.51466	34
27	.53656	.84386	.63584	1.57271	.55121	.83437	.66063	1.51370	33
28	.53681	.84370	.63625	1.57170	.55145	.83421	.66105	1.51275	32
29	.53705	.84355	.63666	1.57069	.55169	.83405	.66147	1.51179	31
30	.53730	.84339	.63707	1.56969	.55194	.83389	.66189	1.51084	30
31	.53754	.84324	.63748	1.56868	.55218	.83373	.66230	1.50988	29
32	.53779	.84308	.63789	1.56767	.55242	.83356	.66272	1.50893	28
33	.53804	.84292	.63830	1.56667	.55266	.83340	.66314	1.50797	27
34	.53828	.84277	.63871	1.56566	.55291	.83324	.66356	1.50702	26
35	.53853	.84261	.63912	1.56466	.55315	.83308	.66398	1.50607	25
36	.53877	.84245	.63953	1.56366	.55339	.83292	.66440	1.50512	24
37	.53902	.84230	.63994	1.56265	.55363	.83276	.66482	1.50417	23
38	.53926	.84214	.64035	1.56165	.55388	.83260	.66524	1.50322	22
39	.53951	.84198	.64076	1.56065	.55412	.83244	.66566	1.50228	21
40	.53975	.84182	.64117	1.55966	.55436	.83228	.66608	1.50133	20
41	.54000	.84167	.64158	1.55866	.55460	.83212	.66650	1.50038	19
42	.54024	.84151	.64199	1.55766	.55484	.83195	.66692	1.49944	18
43	.54049	.84135	.64240	1.55666	.55509	.83179	.66734	1.49849	17
44	.54073	.84120	.64281	1.55567	.55533	.83163	.66776	1.49755	16
45	.54097	.84104	.64322	1.55467	.55557	.83147	.66818	1.49661	15
46	.54122	.84088	.64363	1.55368	.55581	.83131	.66860	1.49566	14
47	.54146	.84072	.64404	1.55269	.55605	.83115	.66902	1.49472	13
48	.54171	.84057	.64446	1.55170	.55630	.83098	.66944	1.49378	12
49	.54195	.84041	.64487	1.55071	.55654	.83082	.66986	1.49284	11
50	.54220	.84025	.64528	1.54972	.55678	.83066	.67028	1.49190	10
51	.54244	.84009	.64569	1.54873	.55702	.83050	.67071	1.49097	9
52	.54269	.83994	.64610	1.54774	.55726	.83034	.67113	1.49003	8
53	.54293	.83978	.64652	1.54675	.55750	.83017	.67155	1.48909	7
54	.54317	.83962	.64693	1.54576	.55775	.83001	.67197	1.48816	6
55	.54342	.83946	.64734	1.54478	.55799	.82985	.67239	1.48722	5
56	.54366	.83930	.64775	1.54379	.55823	.82969	.67282	1.48629	4
57	.54391	.83915	.64817	1.54281	.55847	.82953	.67324	1.48536	3
58	.54415	.83899	.64858	1.54183	.55871	.82936	.67366	1.48442	2
59	.54440	.83883	.64899	1.54085	.55895	.82920	.67409	1.48349	1
60	.54464	.83867	.64941	1.53986	.55919	.82904	.67451	1.48256	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	34°				35°				
	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.55919	.82904	.67451	1.48256	.57358	.81915	.70021	1.42815	60
1	.55943	.82887	.67493	1.48163	.57381	.81899	.70064	1.42726	59
2	.55968	.82871	.67536	1.48070	.57405	.81882	.70107	1.42638	58
3	.55992	.82855	.67578	1.47977	.57429	.81865	.70151	1.42550	57
4	.56016	.82839	.67620	1.47885	.57453	.81848	.70194	1.42462	56
5	.56040	.82822	.67663	1.47792	.57477	.81832	.70238	1.42374	55
6	.56064	.82806	.67705	1.47699	.57501	.81815	.70281	1.42286	54
7	.56088	.82790	.67748	1.47607	.57524	.81798	.70325	1.42198	53
8	.56112	.82773	.67790	1.47514	.57548	.81782	.70368	1.42110	52
9	.56136	.82757	.67832	1.47422	.57572	.81765	.70412	1.42022	51
10	.56160	.82741	.67875	1.47330	.57596	.81748	.70455	1.41934	50
11	.56184	.82724	.67917	1.47238	.57619	.81731	.70499	1.41847	49
12	.56208	.82708	.67960	1.47146	.57643	.81714	.70542	1.41759	48
13	.56232	.82692	.68002	1.47053	.57667	.81698	.70586	1.41672	47
14	.56256	.82675	.68045	1.46962	.57691	.81681	.70629	1.41584	46
15	.56280	.82659	.68088	1.46870	.57715	.81664	.70673	1.41497	45
16	.56305	.82643	.68130	1.46778	.57738	.81647	.70717	1.41409	44
17	.56329	.82626	.68173	1.46686	.57762	.81631	.70760	1.41322	43
18	.56353	.82610	.68215	1.46595	.57786	.81614	.70804	1.41235	42
19	.56377	.82593	.68258	1.46503	.57810	.81597	.70848	1.41148	41
20	.56401	.82577	.68301	1.46411	.57833	.81580	.70891	1.41061	40
21	.56425	.82561	.68343	1.46320	.57857	.81563	.70935	1.40974	39
22	.56449	.82544	.68386	1.46229	.57881	.81546	.70979	1.40887	38
23	.56473	.82528	.68429	1.46137	.57904	.81530	.71023	1.40800	37
24	.56497	.82511	.68471	1.46046	.57928	.81513	.71066	1.40714	36
25	.56521	.82495	.68514	1.45955	.57952	.81496	.71110	1.40627	35
26	.56545	.82478	.68557	1.45864	.57976	.81479	.71154	1.40540	34
27	.56569	.82462	.68600	1.45773	.57999	.81462	.71198	1.40454	33
28	.56593	.82446	.68642	1.45682	.58023	.81445	.71242	1.40367	32
29	.56617	.82429	.68685	1.45592	.58047	.81428	.71285	1.40281	31
30	.56641	.82413	.68728	1.45501	.58070	.81412	.71329	1.40195	30
31	.56665	.82396	.68771	1.45410	.58094	.81395	.71373	1.40109	29
32	.56689	.82380	.68814	1.45320	.58118	.81378	.71417	1.40022	28
33	.56713	.82363	.68857	1.45229	.58141	.81361	.71461	1.39936	27
34	.56736	.82347	.68900	1.45139	.58165	.81344	.71505	1.39850	26
35	.56760	.82330	.68942	1.45049	.58189	.81327	.71549	1.39764	25
36	.56784	.82314	.68985	1.44958	.58212	.81310	.71593	1.39679	24
37	.56803	.82297	.69028	1.44868	.58236	.81293	.71637	1.39593	23
38	.56832	.82281	.69071	1.44778	.58260	.81276	.71681	1.39507	22
39	.56856	.82264	.69114	1.44688	.58283	.81259	.71725	1.39421	21
40	.56880	.82248	.69157	1.44598	.58307	.81242	.71769	1.39336	20
41	.56904	.82231	.69200	1.44508	.58330	.81225	.71813	1.39250	19
42	.56928	.82214	.69243	1.44418	.58354	.81208	.71857	1.39165	18
43	.56952	.82198	.69286	1.44329	.58378	.81191	.71901	1.39079	17
44	.56976	.82181	.69329	1.44239	.58401	.81174	.71946	1.38994	16
45	.57000	.82165	.69372	1.44149	.58425	.81157	.71990	1.38909	15
46	.57024	.82148	.69416	1.44060	.58449	.81140	.72034	1.38824	14
47	.57047	.82132	.69459	1.43970	.58472	.81123	.72078	1.38738	13
48	.57071	.82115	.69502	1.43881	.58496	.81106	.72122	1.38653	12
49	.57095	.82098	.69545	1.43792	.58519	.81089	.72167	1.38568	11
50	.57119	.82082	.69588	1.43703	.58543	.81072	.72211	1.38484	10
51	.57143	.82065	.69631	1.43614	.58567	.81055	.72255	1.38399	9
52	.57167	.82048	.69675	1.43525	.58590	.81038	.72299	1.38314	8
53	.57191	.82032	.69718	1.43436	.58614	.81021	.72344	1.38229	7
54	.57215	.82015	.69761	1.43347	.58637	.81004	.72388	1.38145	6
55	.57238	.81999	.69804	1.43258	.58661	.80987	.72432	1.38060	5
56	.57262	.81982	.69847	1.43169	.58684	.80970	.72477	1.37976	4
57	.57286	.81965	.69891	1.43080	.58708	.80953	.72521	1.37891	3
58	.57310	.81949	.69934	1.42992	.58731	.80936	.72565	1.37807	2
59	.57334	.81932	.69977	1.42903	.58755	.80919	.72610	1.37722	1
60	.57358	.81915	.70021	1.42815	.58779	.80902	.72654	1.37638	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

'	36° Sin.	36° Cos.	36° Tan.	36° Cot.	37° Sin.	37° Cos.	37° Tan.	37° Cot.	'
0	.58779	.80902	.72654	1.37638	.60182	.79864	.75355	1.32704	60
1	.58802	.80885	.72699	1.37554	.60205	.79846	.75401	1.32624	59
2	.58826	.80867	.72743	1.37470	.60228	.79829	.75447	1.32544	58
3	.58849	.80850	.72788	1.37386	.60251	.79811	.75492	1.32464	57
4	.58873	.80833	.72832	1.37302	.60274	.79793	.75538	1.32384	56
5	.58896	.80816	.72877	1.37218	.60298	.79776	.75584	1.32304	55
6	.58920	.80799	.72921	1.37134	.60321	.79758	.75629	1.32224	54
7	.58943	.80782	.72966	1.37050	.60344	.79741	.75675	1.32144	53
8	.58967	.80765	.73010	1.36967	.60367	.79723	.75721	1.32064	52
9	.58990	.80748	.73055	1.36883	.60390	.79706	.75767	1.31984	51
10	.59014	.80730	.73100	1.36800	.60414	.79688	.75812	1.31904	50
11	.59037	.80713	.73144	1.36716	.60437	.79671	.75858	1.31825	49
12	.59061	.80696	.73189	1.36633	.60460	.79653	.75904	1.31745	48
13	.59084	.80679	.73234	1.36549	.60483	.79635	.75950	1.31666	47
14	.59108	.80662	.73278	1.36466	.60506	.79618	.75996	1.31586	46
15	.59131	.80644	.73323	1.36383	.60529	.79600	.76042	1.31507	45
16	.59154	.80627	.73368	1.36300	.60553	.79583	.76088	1.31427	44
17	.59178	.80610	.73413	1.36217	.60576	.79565	.76134	1.31348	43
18	.59201	.80593	.73457	1.36134	.60599	.79547	.76180	1.31269	42
19	.59225	.80576	.73502	1.36051	.60622	.79530	.76226	1.31190	41
20	.59248	.80558	.73547	1.35968	.60645	.79512	.76272	1.31110	40
21	.59272	.80541	.73592	1.35885	.60668	.79494	.76318	1.31031	39
22	.59295	.80524	.73637	1.35802	.60691	.79477	.76364	1.30952	38
23	.59318	.80507	.73681	1.35719	.60714	.79459	.76410	1.30873	37
24	.59342	.80489	.73726	1.35637	.60738	.79441	.76456	1.30795	36
25	.59365	.80472	.73771	1.35554	.60761	.79424	.76502	1.30716	35
26	.59389	.80455	.73816	1.35472	.60784	.79406	.76548	1.30637	34
27	.59412	.80438	.73861	1.35389	.60807	.79388	.76594	1.30558	33
28	.59436	.80420	.73906	1.35307	.60830	.79371	.76640	1.30480	32
29	.59459	.80403	.73951	1.35224	.60853	.79353	.76686	1.30401	31
30	.59482	.80386	.73996	1.35142	.60876	.79335	.76733	1.30323	30
31	.59506	.80368	.74041	1.35060	.60899	.79318	.76779	1.30244	29
32	.59529	.80351	.74086	1.34978	.60922	.79300	.76825	1.30166	28
33	.59552	.80334	.74131	1.34896	.60945	.79282	.76871	1.30087	27
34	.59576	.80316	.74176	1.34814	.60968	.79264	.76918	1.30009	26
35	.59599	.80299	.74221	1.34732	.60991	.79247	.76964	1.29931	25
36	.59622	.80282	.74267	1.34650	.61015	.79229	.77010	1.29853	24
37	.59646	.80264	.74312	1.34568	.61038	.79211	.77057	1.29775	23
38	.59669	.80247	.74357	1.34487	.61061	.79193	.77103	1.29696	22
39	.59693	.80230	.74402	1.34405	.61084	.79176	.77149	1.29618	21
40	.59716	.80212	.74447	1.34323	.61107	.79158	.77196	1.29541	20
41	.59739	.80195	.74492	1.34242	.61130	.79140	.77242	1.29463	19
42	.59763	.80178	.74538	1.34160	.61153	.79122	.77289	1.29385	18
43	.59786	.80160	.74583	1.34079	.61176	.79105	.77335	1.29307	17
44	.59809	.80143	.74628	1.33998	.61199	.79087	.77382	1.29229	16
45	.59832	.80125	.74674	1.33916	.61222	.79069	.77428	1.29152	15
46	.59856	.80108	.74719	1.33835	.61245	.79051	.77475	1.29074	14
47	.59879	.80091	.74764	1.33754	.61268	.79033	.77521	1.28997	13
48	.59902	.80073	.74810	1.33673	.61291	.79016	.77568	1.28919	12
49	.59926	.80056	.74855	1.33592	.61314	.78998	.77615	1.28842	11
50	.59949	.80038	.74900	1.33511	.61337	.78980	.77661	1.28764	10
51	.59972	.80021	.74946	1.33430	.61360	.78962	.77708	1.28687	9
52	.59995	.80003	.74991	1.33349	.61383	.78944	.77754	1.28610	8
53	.60019	.79986	.75037	1.33268	.61406	.78926	.77801	1.28533	7
54	.60042	.79968	.75082	1.33187	.61429	.78908	.77848	1.28456	6
55	.60065	.79951	.75128	1.33107	.61451	.78891	.77895	1.28379	5
56	.60089	.79934	.75173	1.33026	.61474	.78873	.77941	1.28302	4
57	.60112	.79916	.75219	1.32946	.61497	.78855	.77988	1.28225	3
58	.60135	.79899	.75264	1.32865	.61520	.78837	.78035	1.28148	2
59	.60158	.79881	.75310	1.32785	.61543	.78819	.78082	1.28071	1
60	.60182	.79864	.75355	1.32704	.61566	.78801	.78129	1.27994	0
'	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	38°				39°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	·61566	·78801	·78129	1·27994	·62932	·77715	·80978	1·23490	60
1	·61589	·78783	·78175	1·27917	·62955	·77696	·81027	1·23416	59
2	·61612	·78765	·78222	1·27841	·62977	·77678	·81075	1·23343	58
3	·61635	·78747	·78269	1·27764	·63000	·77660	·81123	1·23270	57
4	·61658	·78729	·78316	1·27688	·63022	·77641	·81171	1·23196	56
5	·61681	·78711	·78363	1·27611	·63045	·77623	·81220	1·23123	55
6	·61704	·78694	·78410	1·27535	·63068	·77605	·81268	1·23050	54
7	·61726	·78676	·78457	1·27458	·63090	·77586	·81316	1·22977	53
8	·61749	·78658	·78504	1·27382	·63113	·77568	·81364	1·22904	52
9	·61772	·78640	·78551	1·27306	·63135	·77550	·81413	1·22831	51
10	·61795	·78622	·78598	1·27230	·63158	·77531	·81461	1·22758	50
11	·61818	·78604	·78645	1·27153	·63180	·77513	·81510	1·22685	49
12	·61841	·78586	·78692	1·27077	·63203	·77494	·81558	1·22612	48
13	·61864	·78568	·78739	1·27001	·63225	·77476	·81606	1·22539	47
14	·61887	·78550	·78786	1·26925	·63248	·77458	·81655	1·22467	46
15	·61909	·78532	·78834	1·26849	·63271	·77439	·81703	1·22394	45
16	·61932	·78514	·78881	1·26774	·63293	·77421	·81752	1·22321	44
17	·61955	·78496	·78928	1·26698	·63316	·77402	·81800	1·22249	43
18	·61978	·78478	·78975	1·26622	·63338	·77384	·81849	1·22176	42
19	·62001	·78460	·79022	1·26546	·63361	·77366	·81898	1·22104	41
20	·62024	·78442	·79070	1·26471	·63383	·77347	·81946	1·22031	40
21	·62046	·78424	·79117	1·26395	·63406	·77329	·81995	1·21959	39
22	·62069	·78405	·79164	1·26319	·63428	·77310	·82044	1·21886	38
23	·62092	·78387	·79212	1·26244	·63451	·77292	·82092	1·21814	37
24	·62115	·78369	·79259	1·26169	·63473	·77273	·82141	1·21742	36
25	·62138	·78351	·79306	1·26093	·63496	·77255	·82190	1·21670	35
26	·62160	·78333	·79354	1·26018	·63518	·77236	·82238	1·21598	34
27	·62183	·78315	·79401	1·25943	·63540	·77218	·82287	1·21526	33
28	·62206	·78297	·79449	1·25867	·63563	·77199	·82336	1·21454	32
29	·62229	·78279	·79496	1·25792	·63585	·77181	·82385	1·21382	31
30	·62251	·78261	·79544	1·25717	·63608	·77162	·82434	1·21310	30
31	·62274	·78243	·79591	1·25642	·63630	·77144	·82483	1·21238	29
32	·62297	·78225	·79639	1·25567	·63653	·77125	·82531	1·21166	28
33	·62320	·78206	·79686	1·25492	·63675	·77107	·82580	1·21094	27
34	·62342	·78188	·79734	1·25417	·63698	·77088	·82629	1·21023	26
35	·62365	·78170	·79781	1·25343	·63720	·77070	·82678	1·20951	25
36	·62388	·78152	·79829	1·25268	·63742	·77051	·82727	1·20879	24
37	·62411	·78134	·79877	1·25193	·63765	·77033	·82776	1·20808	23
38	·62433	·78116	·79924	1·25118	·63787	·77014	·82825	1·20736	22
39	·62456	·78098	·79972	1·25044	·63810	·76996	·82874	1·20665	21
40	·62479	·78079	·80020	1·24969	·63832	·76977	·82923	1·20593	20
41	·62502	·78061	·80067	1·24895	·63854	·76959	·82972	1·20522	19
42	·62524	·78043	·80115	1·24820	·63877	·76940	·83022	1·20451	18
43	·62547	·78025	·80163	1·24746	·63899	·76921	·83071	1·20379	17
44	·62570	·78007	·80211	1·24672	·63922	·76903	·83120	1·20308	16
45	·62592	·77988	·80258	1·24597	·63944	·76884	·83169	1·20237	15
46	·62615	·77970	·80306	1·24523	·63966	·76866	·83218	1·20166	14
47	·62638	·77952	·80354	1·24449	·63989	·76847	·83268	1·20095	13
48	·62660	·77934	·80402	1·24375	·64011	·76828	·83317	1·20024	12
49	·62683	·77916	·80450	1·24301	·64033	·76810	·83366	1·19953	11
50	·62706	·77897	·80498	1·24227	·64056	·76791	·83415	1·19882	10
51	·62728	·77879	·80546	1·24153	·64078	·76772	·83465	1·19811	9
52	·62751	·77861	·80594	1·24079	·64100	·76754	·83514	1·19740	8
53	·62774	·77843	·80642	1·24005	·64123	·76735	·83564	1·19669	7
54	·62796	·77824	·80690	1·23931	·64145	·76717	·83613	1·19599	6
55	·62819	·77806	·80738	1·23858	·64167	·76698	·83662	1·19528	5
56	·62842	·77788	·80786	1·23784	·64190	·76679	·83712	1·19457	4
57	·62864	·77769	·80834	1·23710	·64212	·76661	·83761	1·19387	3
58	·62887	·77751	·80882	1·23637	·64234	·76642	·83811	1·19316	2
59	·62909	·77733	·80930	1·23563	·64256	·76623	·83860	1·19246	1
60	·62932	·77715	·80978	1·23490	·64279	·76604	·83910	1·19175	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

′	40° Sin.	40° Cos.	40° Tan.	40° Cot.	41° Sin.	41° Cos.	41° Tan.	41° Cot.	′
0	.64279	.76604	.83910	1.19175	.65606	.75471	.86929	1.15037	60
1	.64301	.76586	.83960	1.19105	.65628	.75452	.86980	1.14969	59
2	.64323	.76567	.84009	1.19035	.65650	.75433	.87031	1.14902	58
3	.64346	.76548	.84059	1.18964	.65672	.75414	.87082	1.14834	57
4	.64368	.76530	.84108	1.18894	.65694	.75395	.87133	1.14767	56
5	.64390	.76511	.84158	1.18824	.65716	.75375	.87184	1.14699	55
6	.64412	.76492	.84208	1.18754	.65738	.75356	.87236	1.14632	54
7	.64435	.76473	.84258	1.18684	.65759	.75337	.87287	1.14565	53
8	.64457	.76455	.84307	1.18614	.65781	.75318	.87338	1.14498	52
9	.64479	.76436	.84357	1.18544	.65803	.75299	.87389	1.14430	51
10	.64501	.76417	.84407	1.18474	.65825	.75280	.87441	1.14363	50
11	.64524	.76398	.84457	1.18404	.65847	.75261	.87492	1.14296	49
12	.64546	.76380	.84507	1.18334	.65869	.75241	.87543	1.14229	48
13	.64568	.76361	.84556	1.18264	.65891	.75222	.87595	1.14162	47
14	.64590	.76342	.84606	1.18194	.65913	.75203	.87646	1.14095	46
15	.64612	.76323	.84656	1.18125	.65935	.75184	.87698	1.14028	45
16	.64635	.76304	.84706	1.18055	.65956	.75165	.87749	1.13961	44
17	.64657	.76286	.84756	1.17986	.65978	.75146	.87801	1.13894	43
18	.64679	.76267	.84806	1.17916	.66000	.75126	.87852	1.13828	42
19	.64701	.76248	.84856	1.17846	.66022	.75107	.87904	1.13761	41
20	.64723	.76229	.84906	1.17777	.66044	.75088	.87955	1.13694	40
21	.64746	.76210	.84956	1.17708	.66066	.75069	.88007	1.13627	39
22	.64768	.76192	.85006	1.17638	.66088	.75050	.88059	1.13561	38
23	.64790	.76173	.85057	1.17569	.66109	.75030	.88110	1.13494	37
24	.64812	.76154	.85107	1.17500	.66131	.75011	.88162	1.13428	36
25	.64834	.76135	.85157	1.17430	.66053	.74992	.88204	1.13361	35
26	.64856	.76116	.85207	1.17361	.66175	.74973	.88265	1.13295	34
27	.64878	.76097	.85257	1.17292	.66197	.74953	.88317	1.13228	33
28	.64901	.76078	.85308	1.17223	.66218	.74934	.88369	1.13162	32
29	.64923	.76059	.85358	1.17154	.66240	.74915	.88421	1.13096	31
30	.64945	.76041	.85408	1.17085	.66262	.74896	.88473	1.13029	30
31	.64967	.76022	.85458	1.17016	.66284	.74876	.88524	1.12963	29
32	.64989	.76003	.85509	1.16947	.66306	.74857	.88576	1.12897	28
33	.65011	.75984	.85559	1.16878	.66327	.74838	.88628	1.12831	27
34	.65033	.75965	.85609	1.16809	.66349	.74818	.88680	1.12765	26
35	.65055	.75946	.85660	1.16741	.66371	.74799	.88732	1.12699	25
36	.65077	.75927	.85710	1.16672	.66393	.74780	.88784	1.12633	24
37	.65100	.75908	.85761	1.16603	.66414	.74760	.88836	1.12567	23
38	.65122	.75889	.85811	1.16535	.66436	.74741	.88888	1.12501	22
39	.65144	.75870	.85862	1.16466	.66458	.74722	.88940	1.12435	21
40	.65166	.75851	.85912	1.16398	.66480	.74703	.88992	1.12369	20
41	.65188	.75832	.85963	1.16329	.66501	.74683	.89045	1.12303	19
42	.65210	.75813	.86014	1.16261	.66523	.74664	.89097	1.12238	18
43	.65232	.75794	.86064	1.16192	.66545	.74644	.89149	1.12172	17
44	.65254	.75775	.86115	1.16124	.66566	.74625	.89201	1.12106	16
45	.65276	.75756	.86166	1.16056	.66588	.74606	.89253	1.12041	15
46	.65298	.75738	.86216	1.15987	.66610	.74586	.89306	1.11975	14
47	.65320	.75719	.86267	1.15919	.66632	.74567	.89358	1.11909	13
48	.65342	.75700	.86318	1.15851	.66653	.74548	.89410	1.11844	12
49	.65364	.75680	.86368	1.15783	.66675	.74528	.89463	1.11778	11
50	.65386	.75661	.86419	1.15715	.66697	.74509	.89515	1.11713	10
51	.65408	.75642	.86470	1.15647	.66718	.74489	.89567	1.11648	9
52	.65430	.75623	.86521	1.15579	.66740	.74470	.89620	1.11582	8
53	.65452	.75604	.86572	1.15511	.66762	.74451	.89672	1.11517	7
54	.65474	.75585	.86623	1.15443	.66783	.74431	.89725	1.11452	6
55	.65496	.75566	.86674	1.15375	.66805	.74412	.89777	1.11387	5
56	.65518	.75547	.86725	1.15308	.66827	.74392	.89830	1.11321	4
57	.65540	.75528	.86776	1.15240	.66848	.74373	.89883	1.11256	3
58	.65562	.75509	.86827	1.15172	.66870	.74353	.89935	1.11191	2
59	.65584	.75490	.86878	1.15104	.66891	.74334	.89988	1.11126	1
60	.65606	.75471	.86929	1.15037	.66913	.74314	.90040	1.11061	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII.—NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

	42°				43°				
′	Sin.	Cos.	Tan.	Cot.	Sin.	Cos.	Tan.	Cot.	′
0	.66913	.74314	.90040	1.11061	.68200	.73135	.93252	1.07237	60
1	.66935	.74295	.90093	1.10996	.68221	.73116	.93306	1.07174	59
2	.66956	.74276	.90146	1.10931	.68242	.73096	.93360	1.07112	58
3	.66978	.74256	.90199	1.10867	.68264	.73076	.93415	1.07049	57
4	.66999	.74237	.90251	1.10802	.68285	.73056	.93469	1.06987	56
5	.67021	.74217	.90304	1.10737	.68306	.73036	.93524	1.06925	55
6	.67043	.74198	.90357	1.10672	.68327	.73016	.93578	1.06862	54
7	.67064	.74178	.90410	1.10607	.68349	.72996	.93633	1.06800	53
8	.67086	.74159	.90463	1.10543	.68370	.72976	.93688	1.06738	52
9	.67107	.74139	.90516	1.10478	.68391	.72957	.93742	1.06676	51
10	.67129	.74120	.90569	1.10414	.68412	.72937	.93797	1.06613	50
11	.67151	.74100	.90621	1.10349	.68434	.72917	.93852	1.06551	49
12	.67172	.74080	.90674	1.10285	.68455	.72897	.93906	1.06489	48
13	.67194	.74061	.90727	1.10220	.68476	.72877	.93961	1.06427	47
14	.67215	.74041	.90781	1.10156	.68497	.72857	.94016	1.06365	46
15	.67237	.74022	.90834	1.10091	.68518	.72837	.94071	1.06303	45
16	.67258	.74002	.90887	1.10027	.68539	.72817	.94125	1.06241	44
17	.67280	.73983	.90940	1.09963	.68561	.72797	.94180	1.06179	43
18	.67301	.73963	.90993	1.09899	.68582	.72777	.94235	1.06117	42
19	.67323	.73944	.91046	1.09834	.68603	.72757	.94290	1.06056	41
20	.67344	.73924	.91099	1.09770	.68624	.72737	.94345	1.05994	40
21	.67366	.73904	.91153	1.09706	.68645	.72717	.94400	1.05932	39
22	.67387	.73885	.91206	1.09642	.68666	.72697	.94455	1.05870	38
23	.67409	.73865	.91259	1.09578	.68688	.72677	.94510	1.05809	37
24	.67430	.73846	.91313	1.09514	.68709	.72657	.94565	1.05747	36
25	.67452	.73826	.91366	1.09450	.68730	.72637	.94620	1.05685	35
26	.67473	.73806	.91419	1.09386	.68751	.72617	.94676	1.05624	34
27	.67495	.73787	.91473	1.09322	.68772	.72597	.94731	1.05562	33
28	.67516	.73767	.91526	1.09258	.68793	.72577	.94786	1.05501	32
29	.67538	.73747	.91580	1.09195	.68814	.72557	.94841	1.05439	31
30	.67559	.73728	.91633	1.09131	.68835	.72537	.94896	1.05378	30
31	.67580	.73708	.91687	1.09067	.68857	.72517	.94952	1.05317	29
32	.67602	.73688	.91740	1.09003	.68878	.72497	.95007	1.05255	28
33	.67623	.73669	.91794	1.08940	.68899	.72477	.95062	1.05194	27
34	.67645	.73649	.91847	1.08876	.68920	.72457	.95118	1.05133	26
35	.67666	.73629	.91901	1.08813	.68941	.72437	.95173	1.05072	25
36	.67688	.73610	.91955	1.08749	.68962	.72417	.95229	1.05010	24
37	.67709	.73590	.92008	1.08686	.68983	.72397	.95284	1.04949	23
38	.67730	.73570	.92062	1.08622	.69004	.72377	.95340	1.04888	22
39	.67752	.73551	.92116	1.08559	.69025	.72357	.95395	1.04827	21
40	.67773	.73531	.92170	1.08496	.69046	.72337	.95451	1.04766	20
41	.67795	.73511	.92224	1.08432	.69067	.72317	.95506	1.04705	19
42	.67816	.73491	.92277	1.08369	.69088	.72297	.95562	1.04644	18
43	.67837	.73472	.92331	1.08306	.69109	.72277	.95618	1.04583	17
44	.67859	.73452	.92385	1.08243	.69130	.72257	.95673	1.04522	16
45	.67880	.73432	.92439	1.08179	.69151	.72236	.95729	1.04461	15
46	.67901	.73413	.92493	1.08116	.69172	.72216	.95785	1.04401	14
47	.67923	.73393	.92547	1.08053	.69193	.72196	.95841	1.04340	13
48	.67944	.73373	.92601	1.07990	.69214	.72176	.95897	1.04279	12
49	.67965	.73353	.92655	1.07927	.69235	.72156	.95952	1.04218	11
50	.67987	.73333	.92709	1.07864	.69256	.72136	.96008	1.04158	10
51	.68008	.73314	.92763	1.07801	.69277	.72116	.96064	1.04097	9
52	.68029	.73294	.92817	1.07738	.69298	.72095	.96120	1.04036	8
53	.68051	.73274	.92872	1.07676	.69319	.72075	.96176	1.03976	7
54	.68072	.73254	.92926	1.07613	.69340	.72055	.96232	1.03915	6
55	.68093	.73234	.92980	1.07550	.69361	.72035	.96288	1.03855	5
56	.68115	.73215	.93034	1.07487	.69382	.72015	.96344	1.03794	4
57	.68136	.73195	.93088	1.07425	.69403	.71995	.96400	1.03734	3
58	.68157	.73175	.93143	1.07362	.69424	.71974	.96457	1.03674	2
59	.68179	.73155	.93197	1.07299	.69445	.71954	.96513	1.03613	1
60	.68200	.73135	.93252	1.07237	.69466	.71934	.96569	1.03553	0
′	Cos.	Sin.	Cot.	Tan.	Cos.	Sin.	Cot.	Tan.	′

TABLE XIII. — NATURAL SINES, COSINES, TANGENTS, AND COTANGENTS.

′	Sin.	Cos.	Tan.	Cot.	′
		44°			
0	.69466	.71934	.96569	1.03553	60
1	.69487	.71914	.96625	1.03493	59
2	.69508	.71894	.96681	1.03433	58
3	.69529	.71873	.96738	1.03372	57
4	.69549	.71853	.96794	1.03312	56
5	.69570	.71833	.96850	1.03252	55
6	.69591	.71813	.96907	1.03192	54
7	.69612	.71792	.96963	1.03132	53
8	.69633	.71772	.97020	1.03072	52
9	.69654	.71752	.97076	1.03012	51
10	.69675	.71732	.97133	1.02952	50
11	.69696	.71711	.97189	1.02892	49
12	.69717	.71691	.97246	1.02832	48
13	.69737	.71671	.97302	1.02772	47
14	.69758	.71650	.97359	1.02713	46
15	.69779	.71630	.97416	1.02653	45
16	.69800	.71610	.97472	1.02593	44
17	.69821	.71590	.97529	1.02533	43
18	.69842	.71569	.97586	1.02474	42
19	.69862	.71549	.97643	1.02414	41
20	.69883	.71529	.97700	1.02355	40
21	.69904	.71508	.97756	1.02295	39
22	.69925	.71488	.97813	1.02236	38
23	.69946	.71468	.97870	1.02176	37
24	.69966	.71447	.97927	1.02117	36
25	.69987	.71427	.97984	1.02057	35
26	.70008	.71407	.98041	1.01998	34
27	.70029	.71386	.98098	1.01939	33
28	.70049	.71366	.98155	1.01879	32
29	.70070	.71345	.98213	1.01820	31
30	.70091	.71325	.98270	1.01761	30
′	Cos.	Sin.	Cot.	Tan.	′
		45°			

′	Sin.	Cos.	Tan.	Cot.	′
		44°			
30	.70091	.71325	.98270	1.01761	30
31	.70112	.71305	.98327	1.01702	29
32	.70132	.71284	.98384	1.01642	28
33	.70153	.71264	.98441	1.01583	27
34	.70174	.71243	.98499	1.01524	26
35	.70195	.71223	.98556	1.01465	25
36	.70215	.71203	.98613	1.01406	24
37	.70236	.71182	.98671	1.01347	23
38	.70257	.71162	.98728	1.01288	22
39	.70277	.71141	.98786	1.01229	21
40	.70298	.71121	.98843	1.01170	20
41	.70319	.71100	.98901	1.01112	19
42	.70339	.71080	.98958	1.01053	18
43	.70360	.71059	.99016	1.00994	17
44	.70381	.71039	.99073	1.00935	16
45	.70401	.71019	.99131	1.00876	15
46	.70422	.70998	.99189	1.00818	14
47	.70443	.70978	.99247	1.00759	13
48	.70463	.70957	.99304	1.00701	12
49	.70484	.70937	.99362	1.00642	11
50	.70505	.70916	.99420	1.00583	10
51	.70525	.70896	.99478	1.00525	9
52	.70546	.70875	.99536	1.00467	8
53	.70567	.70855	.99594	1.00408	7
54	.70587	.70834	.99652	1.00350	6
55	.70608	.70813	.99710	1.00291	5
56	.70628	.70793	.99768	1.00233	4
57	.70649	.70772	.99826	1.00175	3
58	.70670	.70752	.99884	1.00116	2
59	.70690	.70731	.99942	1.00058	1
60	.70711	.70711	1.00000	1.00000	0
′	Cos.	Sin.	Cot.	Tan.	′
		45°			

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